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WRIGHT STATE UNIV · DAYTON OH SCHOOL OF MEDICINE

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UPDATE OF THE SUMMARY REPORT OF 1977-1978 TASK FORCE ON AIRCREW--ETC(U)  
APR 81 W J COX, F GOLD, R L SULZER

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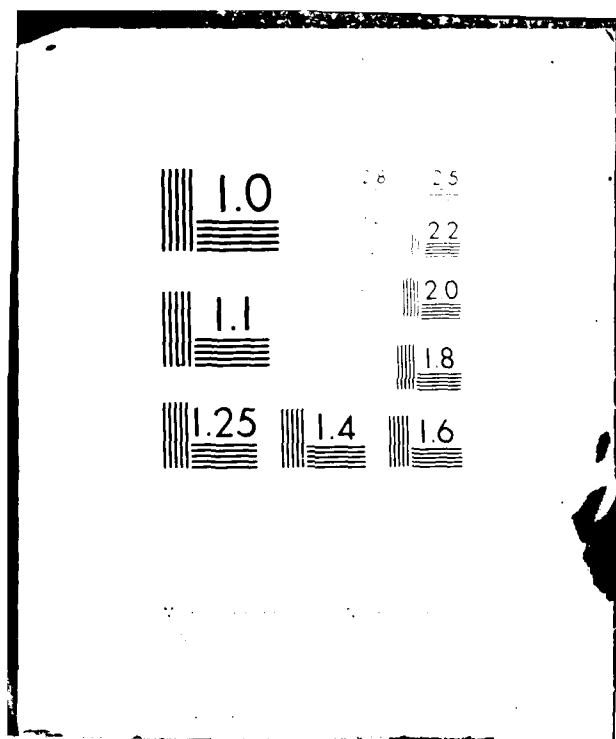
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Systems Research &  
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# Update of the Summary Report of 1977-1978 Task Force on Aircrew Workload

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April 1981

Final Report

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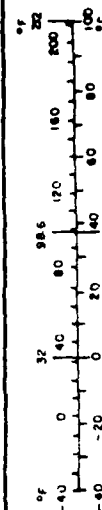
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16. Abstract <p>The 1978 summary of accident data from 1967 through 1976 has been extended through 1979. Comparing accident rates of aircraft types approved for operation by two crewmembers vs. accident rates for those approved for operation by three crewmembers, no indication of a safety problem relating to crew size was found. Over this three-year update period, accident rates per million departures were generally superior for the two-crew aircraft, the same result found for the earlier ten-year period. This nominal superiority is not considered a necessary result of flight deck configuration since there are other important differences in the operating environments of the various aircraft. A separate study has been made of the relationship between crew size and regulatory violations. This study, which is appended, produced no evidence that aircraft with crew size of two are being flown with less compliance than aircraft with a crew size of three.</p>		
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# METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures				Approximate Conversions from Metric Measures			
Symbol	When You Know	Multiply by	To Find	Symbol	When You Know	Multiply by	To Find
<b>LENGTH</b>				<b>LENGTH</b>			
in	inches	2.5	centimeters	mm	millimeters	0.04	inches
ft	feet	30	centimeters	cm	centimeters	0.4	inches
yd	yards	0.9	meters	m	meters	3.3	yards
mi	miles	1.6	kilometers	km	kilometers	0.6	miles
<b>AREA</b>				<b>AREA</b>			
sq in	square inches	6.5	square centimeters	sq cm	square centimeters	0.16	square inches
sq ft	square feet	0.09	square meters	sq m	square meters	1.2	square yards
sq yd	square yards	0.8	square meters	ha	hectares (10,000 m <sup>2</sup> )	0.4	square miles
sq mi	square miles	2.6	square kilometers	sq mi	square miles	2.5	hectares
ac	acres	0.4	hectares	<b>MASS (weight)</b>			
<b>MASS (weight)</b>				<b>MASS (weight)</b>			
oz	ounces	28	grams	g	grams	0.035	ounces
lb	pounds	0.45	kilograms	kg	kilograms	2.2	pounds
sh (2000 lb)	short tons	0.9	tonnes	t	tonnes (1000 kg)	1.1	short tons
<b>VOLUME</b>				<b>VOLUME</b>			
ts	teaspoons	5	milliliters	ml	milliliters	0.03	fluid ounces
tblsp	tablespoons	15	milliliters	l	liters	2.1	pints
fl oz	fluid ounces	30	milliliters	m <sup>3</sup>	cubic meters	1.06	quarts
c	cups	0.24	liters	m <sup>3</sup>	cubic meters	0.26	gallons
pt	pints	0.47	liters	m <sup>3</sup>	cubic meters	35	cubic feet
qt	quarts	0.96	liters	m <sup>3</sup>	cubic meters	1.3	cubic yards
gal	gallons	3.8	liters	<b>TEMPERATURE (exact)</b>			
cu ft	cubic feet	0.03	cubic meters	°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature
cu yd	cubic yards	0.76	cubic meters	<b>TEMPERATURE (exact)</b>			
<b>TEMPERATURE (exact)</b>				<b>TEMPERATURE (exact)</b>			
F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature

For other exact conversions and more data, consult the Metric Conversion Tables, NIST Monograph 437-1, 1975, U.S. Government Printing Office, Washington, D.C. 20540. Price \$2.25. SC Catalog No. C-13-296.



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## Introduction:

After the summary report of 1977-1978 Task Force on Crew Workload was published in December, 1978, interest has continued in the operational importance of the size of flight crews in turbojet air carrier aircraft. Various studies and analyses of portions of the accident, incident, and violation data have been developed, and proponents of a rule requiring a minimum crew of three in all future aircraft have rejected the conclusion that crew size is not an important determinant of operating safety (see ref 1, 2, 3, 4, and 5). The purpose of this update of the earlier Task Force report is to extend the data base over the additional three years experience now available from the National Transportation Safety Board (NTSB), and to clarify the choice of methods available for selective sampling.

Based on the accidents occurring in 1967 through 1976, it was concluded that differences between two- and three-crew aircraft were not significant (see ref 1). This outcome was the same whether the comparison was made on all accidents, all fatal accidents, or all accidents reduced by normalizing. ("Normalizing" is the conservative process that deletes categories of accidents which could not represent in-flight aircrew involvement.) Proponents of three-crew design generally accepted the 1978 finding that accident statistics do not prove the need for any particular crew size. They did, however, criticize the normalizing procedure used by the 1977-1978 Task Force (see ref 4). Due to the continuation of this discussion, the alternative sampling procedures should be restated.

To make a crucial test of the relation between accidents and crew size, it would be desirable to select only those accidents caused by the crew or potentially preventable by crew actions. But an exact sorting out of the total accident experience to reduce down to those "known" crew related accidents is not feasible. The reason for this is that we must work with the attributions of cause that are made by the NTSB, and NTSB has never claimed to be able to identify positively every crew involvement. The most complete and objective analysis of most U.S. air carrier accidents is that provided by NTSB, but in the case of many accident reports, there is no conclusive reason for NTSB to either attribute the cause to specific crew actions or to absolutely absolve the crew from possible involvement. Often uncertainty as to exactly what happened or might have been caused to happen differently is revealed in surviving crewmember testimony. Non-survivable accidents, such as the PSA B-727 midair collision at San Diego or the American DC-10 engine-separation accident at Chicago, often leave questions concerning possible crew actions that might have reduced the severity of the accidents. It is speculative, then, to set forth a list of crew-caused accidents and assert that these constitute the single best sample.

The more acceptable procedure is to base the accident comparisons on: a) the total accident experience with no selective deletions; b) the total

fatal accident experience, because fatal accidents are of obvious great importance; and on c) a conservative selection procedure that avoids making speculative assumptions that would not be accepted by some reasonable persons. The normalizing process used herein is considered to be such a conservative selection process. All accidents are included other than those falling into categories that clearly and without exception are not primarily assignable to crew actions: Turbulence accidents, ground accidents that occurred when the aircraft was not moving, and aircraft component structural failure caused accidents.

Even turbulence accidents might, in some cases, be attributed to crew actions or inactions. For example, in some individual cases, crews have been criticized for excessive airspeed and navigation procedures when turbulence was suspected. Because of longer average stage lengths and greater average seating capacity, turbulence accidents may be expected to be more frequent, by departure cycle measures, in three-crew aircraft, the class that includes most of the large capacity, long-range aircraft. Because of this, eliminating turbulence accidents tends to favor three-crew aircraft as a class in any comparison with smaller, shorter stage-length, two-crew aircraft. Since total accident statistics tended to favor two-crew aircraft in the earlier ten-year analysis, it was deemed acceptable to eliminate the large class of turbulence accidents on the assumptions that these accidents are mostly unavoidable, and to the extent that they are avoidable, no injustice would be done to the three-crew concept by their deletion. These same assumptions cannot be supported in the case of various other possible categories of accidents occurring in-flight. Either the circumstances of cause appear to be unique, leaving no general rule for selection, or a tendency to bias the comparison against the larger, three-crew aircraft was anticipated.

#### Discussion:

To keep the information parallel to that presented in the Summary Report of 1977-1978 Task Force on Crew Workload, the update data are tabulated by total accidents, normalized accidents (total minus certain categories that clearly cannot be attributed to crew actions or failures to act), and fatal accidents. For the earlier ten-year period, the five aircraft types had experienced a grand total of 202 accidents of which 27 were fatal accidents. The normalizing procedure deleted from the 202 total a group of 87 accidents (principally enroute passenger and cabin attendant injuries caused by turbulence and accidents caused by events that occurred while the aircraft was stationary on the ground), leaving the normalized sample at 115 accidents. In Table 1, the resulting three-year totals in each of the three categories are presented for the same five aircraft types covered in the ten-year analysis in the earlier report. Table 2 compresses the same summary to a comparison between pooled three-crew aircraft and pooled two-crew aircraft.

Examination of the data in Table 1 reveals essentially the same trends that were shown in the earlier ten-year tables. For the latter three years, those for the DC-8 remained the highest total, normalized, and fatal accident rates by a wide margin. The DC-8 is, of course, the only first-generation turbojet in the table, and it is known that later developed aircraft have shown improved accident rates. The other three-crew aircraft, the B-727 and the three-crew operated B-737, show accident rates which closely approximate the overall means. The two-crew aircraft, however, all show total accident rates below the overall grand mean.

Table 2, again, presents an analogy to the earlier ten-year data. Total accident rate is higher for the three-crew aircraft, when they are pooled into one group, and the total, normalized, and fatal accident rates for the pooled two-crew aircraft are lower. Obviously, the comparisons between pooled two-crew and pooled three-crew aircraft would have been closer without inclusion of the DC-8, but the results still show a superior set of accident rates for the pooled two-crew aircraft when they are compared to the three-crew B-727, alone, as shown in Table 1.

Many factors besides crew activities may enter into accident rates. The number of seats occupied by passengers is a factor since any injury to a passenger may result in an accident listing. The differences in operating environments, including airport and weather differences, may be significant. The three-crew DC-8, which has been out of production for several years and which represents a declining portion of the air carrier fleet, compares poorly in accident rates tabulated herein. Otherwise, it does not appear that the single factor of crew-size is a major determinant of accident rates. The several two-crew aircraft have generally lower than average accident rates. At the same time, they average fewer seats, shorter stage lengths, and younger aircraft age. Hence, it is unreasonable to attribute the superior accident rate performance simply to the identifying factor in the tables (crew-size). The more reasonable conclusion is that these data lend no support to the proposition that use of two crewmembers in an appropriately designed aircraft derogates safety.

Appendices I, II, and III contain a U.S. vs non-U.S. world-wide market comparison, summaries of accident data and an update of the accident tables taken from the earlier ten-year summary.

Appendix IV consists of an internal FAA report prepared to consider the relation between crew size and reported violations. The conclusion reached in this report was that the violation data lend no support to the idea that there are more violations with one crew size or another.

TABLE 1  
U.S. Air Carrier Accidents (1977-1979) for  
Five Aircraft Types

Parameter	B-727	DC-8	B-737		DC-9	BAC-1-11	Total
			2M	3M			
Departures (in millions)	5.822	.462	.973	.612	3.609	.320	11.788
Total Accidents	18	10	1	3	6	1	39
Normalized Accidents	10	7	0	0	4	1	22
Fatal Accidents	2	2	0	0	1	0	5
Total Accident Rate	3.09	21.64	1.49	3.43	1.66	3.12	3.32
Normalized Accident Rate	1.72	15.15	0	0	1.11	3.12	1.87
Fatal Accident Rate	.34	4.33	0	0	.28	0	.42
% Total Departures	49.4%	3.9%	8.2%	5.2%	30.6%	2.7%	100%
Hypothetical Total Accidents	19.2	1.52	3.98	2.28	11.93	1.05	
Hypothetical Normalized Accidents	10.89	.86	1.8	1.14	6.73	.59	
Hypothetical Fatal Accidents	2.48	.20	.41	.26	1.53	.14	

TABLE 2  
Summary of Accident Data 1977-1979  
By Number of Crewmembers Flying Aircraft

Aircraft	2-Crew	3-Crew	Total
Departures (in millions)	4.892	6.896	11.788
Total Accidents	8	31	39
Normalized Accidents	5	17	22
Fatal Accidents	1	4	5
Total Accident Rate	1.63	4.49	3.31
Normalized Accident Rate	1.02	2.46	1.87
Fatal Accident Rate	.20	.58	.42
Percent Departures	41.5%	58.5%	100%
Hypothetical Total Accidents	16.18	22.81	
Hypothetical Normalized Accidents	9.13	12.87	
Hypothetical Fatal Accidents	2.07	2.92	

## REFERENCES

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3. Hinz, R.K., Jr., "Refutation of Boeing Complement Presentation," July 23, 1980, Air Line Pilots Association, 1625 Massachusetts Ave., N.W., Washington, D.C. 20036.
4. Glines, C.V. and Morris, M. (Eds), "No Compromise with Safety: The Crew Complement Question," 1980, booklet published by Europilote and U.S. ALPA, 1625 Massachusetts Ave. N.W., Washington, D.C. 20036.
5. Hinz, R.K., Jr., "Continuing Observations on the Inadequacies of the Boeing 11 year Statistical Study of Two Vs. Three Crew Accident Data," 10/29/80 (Rev. 1/4/81), Air Line Pilot Association, 1625 Massachusetts Ave., N.W., Washington, D.C. 20036.

## APPENDIX I

### U.S. vs. Non-U.S. World-Wide Operational Market Comparison

An overall review of world-wide operational market data was updated to include years 1977, 1978, and 1979. These data are included to provide a comparison of the relative size of the U.S. air carrier activities as compared to those of non-U.S. air carriers. This review provided a high level of confidence that the majority of both the world's air carrier aircraft and their departures have been considered.

The data used to determine the U.S. vs. non-U.S. market share were extracted directly from ICAO documents, Digest of Statistics, Nos. 236, 249 and 262, for years 1977, 1978 and 1979, respectively. Comparison of the aircraft departure data contained in these documents and the departure data provided by the U.S. Civil Aeronautics Board, used elsewhere in this report, may not be in absolute agreement.

TABLE I-1

AIR CARRIER FIXED-WING TURBO-JET AIRCRAFT TOTAL U.S. VERSUS NON-U.S. AIRCRAFT  
(MANUFACTURERS AND OPERATORS) WORLD-WIDE MARKET SHARE BY MILLIONS OF DEPARTURES

1977

US Manufacturers

	US Carriers	Non-US Carriers	Total
<u>Boeing</u>	<u>2,352,396</u>	<u>1,445,731</u>	<u>3,798,127</u>
707	255,968	197,167	453,135
720	25,849	38,805	64,654
727	1,596,993	591,832	2,188,825
737	387,588	511,627	899,215
747	85,998	106,300	192,298
<u>Douglas</u>	<u>1,515,142</u>	<u>1,100,954</u>	<u>2,616,096</u>
DC-8	184,964	179,301	364,365
DC-9	1,175,342	832,161	2,007,503
DC-10	154,836	89,492	244,328
<u>Convair</u>	<u>- - - -</u>	<u>9,257</u>	<u>9,257</u>
880	- - - -	14	14
990	- - - -	9,243	9,243
<u>Lockheed</u>	<u>105,926</u>	<u>33,068</u>	<u>138,994</u>
T-101	105,926	33,068	138,994
<u>Total</u>	<u>3,973,464</u>	<u>2,589,010</u>	<u>6,562,474</u>

Non-US Manufacturers

<u>Dassault</u>	<u>- - - -</u>	<u>21,249</u>	<u>21,249</u>
Mercure	- - - -	21,249	21,249
<u>Airbus</u>	<u>482</u>	<u>36,486</u>	<u>36,968</u>
300			
<u>Fokker</u>	<u>- - - -</u>	<u>123,647</u>	<u>123,647</u>
F-28			
<u>Hawker</u>	<u>- - - -</u>	<u>77,011</u>	<u>77,011</u>
HS-106	- - - -	10,346	10,346
HS-121	- - - -	66,274	66,274
HS-125	- - - -	391	391
<u>Ilyushin</u>	<u>- - - -</u>	<u>7,179</u>	<u>7,179</u>
IL-62			
<u>SUD</u>	<u>- - - -</u>	<u>131,645</u>	<u>131,645</u>
SE-210			



1977

Non-US Manufacturers (continued)

	<u>US Carriers</u>	<u>Non-US Carriers</u>	<u>Total</u>
Topolev			
TV-134	- - - -	28,110	28,110
BAC	- - - -	203,979	313,453
T-11	109,474	186,734	296,208
VC-10	- - - -	17,245	17,245
VFW			
614	- - - -	9,082	9,082
Yakovlev			
Yak-40	- - - -	20,159	20,159
<u>Total</u>	109,956	658,547	768,503

1977

	<u>US Carriers</u>		<u>Non-US Carriers</u>		<u>Total</u>
<u>US Manufacturers</u>					
Boeing	2.352	62 <sup>60</sup> / <sub>100</sub>	1.446	38 <sup>30</sup> / <sub>100</sub>	3.798
Douglas	1.515	58 <sup>60</sup> / <sub>100</sub>	1.101	42 <sup>30</sup> / <sub>100</sub>	2.616
Convair	- - - -		.009		.009
Lockheed	.106	76 <sup>60</sup> / <sub>100</sub>	.033	24 <sup>30</sup> / <sub>100</sub>	.139
Total	3.973	60.55 <sup>50</sup> / <sub>100</sub>	2.589	39.45 <sup>30</sup> / <sub>100</sub>	6.562
<u>Non-US Manufacturers</u>					
BAC	.109	37 <sup>30</sup> / <sub>100</sub>	.186	63 <sup>30</sup> / <sub>100</sub>	.296
Dassult	- - - -		.021		.021
Airbus	.0005	1.5 <sup>30</sup> / <sub>100</sub>	.036	98.5 <sup>30</sup> / <sub>100</sub>	.037
Fokker	- - - -		.123		.123
Hawker	- - - -		.077		.077
Ilyushin	- - - -		.007		.007
SUD	- - - -		.131		.131
Topolev	- - - -		.028		.028
VFW	- - - -		.009		.009
Yakovlev	- - - -		.020		.020
Total	.11	14.32 <sup>30</sup> / <sub>100</sub>	.658	85.68 <sup>30</sup> / <sub>100</sub>	.769

Total All Manufacturers/Air Carriers: 7.33

Total US Manufacturers Market Share:  $6.562/7.33 = 89.52\%$

Total US Air Carrier Market Share:  $4.083/7.33 = 55.7\%$

Information is based on departure data extracted directly from ICAO Digest of Statistics No. 236, 1977.

TABLE I-2

AIR CARRIER FIXED-WING TURBO-JET AIRCRAFT TOTAL U.S. VERSUS NON-U.S. AIRCRAFT  
(MANUFACTURERS AND OPERATORS) WORLD-WIDE MARKET SHARE BY MILLIONS OF DEPARTURES

1978

US Manufacturers

	<u>US Carriers</u>	<u>Non-US Carriers</u>	<u>Total</u>
<u>Boeing</u>	<u>2,661,226</u>	<u>1,395,959</u>	<u>4,057,185</u>
707	226,375	189,309	415,684
720	15,049	42,914	57,963
727	1,893,745	514,251	2,407,996
737	436,487	530,762	967,251
747	89,570	118,723	208,293
<u>Douglas</u>	<u>1,567,433</u>	<u>993,987</u>	<u>2,561,420</u>
DC-8	174,122	181,679	355,801
DC-9	1,244,995	720,258	1,965,253
DC-10	148,316	92,050	240,366
<u>Convair</u>			
880	- - - -	265	265
<u>Lockheed</u>			
1011	112,206	32,988	145,194
<u>Total</u>	<u>4,340,865</u>	<u>2,423,199</u>	<u>6,764,064</u>

Non-US Manufacturers

<u>BAC-SUD</u>			
Concorde	- - - -	3,311	3,311
<u>Dassault</u>			
Mercure	- - - -	20,829	20,829
<u>Airbus</u>			
300B	6,216	54,272	60,488
<u>Fokker</u>			
F-28	- - - -	112,100	112,100
<u>Hawker</u>			
HS-106	- - - -	83,121	83,121
HS-121	- - - -	7,874	7,874
HS-125	- - - -	74,889	74,889
	- - - -	358	358

1978

Non-US Manufacturers (continued)

	<u>US Carriers</u>	<u>Non-US Carriers</u>	<u>Total</u>
Ilyushin			
IL-62	- - - -	7,739	7,739
SUD			
SE-210	- - - -	128,246	128,246
Topolev			
TV-134	- - - -	35,512	35,512
BAC	107,428	184,310	291,738
I-11	107,428	172,061	279,489
VC-10	- - - -	12,249	12,249
VFW			
614	- - - -	8,352	8,352
Yakovlev			
Yak-40	- - - -	21,099	21,099
<u>Total</u>	113,644	658,891	772,535

1978

	<u>US Carriers</u>		<u>Non-US Carriers</u>		<u>Total</u>
<u>US Manufacturers</u>					
Boeing	2.661	66%	1.396	34%	4.057
Douglas	1.567	61%	.994	39%	2.561
Convair	- - -		.0003	100%	.0003
Lockheed	.112	77%	.033	22%	.145
<u>Total</u>	<u>4.340</u>	<u>64%</u>	<u>2.423</u>	<u>36%</u>	<u>6.763</u>
<u>Non-US Manufacturers</u>					
BAC-SUD	- - - -		.003		.003
Dassault	- - - -		.021		.021
Airbus	.006	10%	.054	90%	.060
Fokker	- - - -		.112		.112
Hawker	- - - -		.083		.083
Ilyushin	- - - -		.008		.008
SUD	- - - -		.128		.128
Topolev	- - - -		.036		.036
BAC	.107	37%	.184	63%	.291
VFW	- - - -		.008		.008
Yakovlev	- - - -		.021		.021
<u>Total</u>	<u>.113</u>	<u>15%</u>	<u>.658</u>	<u>85%</u>	<u>.772</u>

Total All Manufacturers/Air Carriers: 7.535

Total U.S. Manufacturers Market Share:  $6.763/7.535 = 89.7\%$

Total US Air Carrier Market Share:  $4.340/7.535 = 57.6\%$

Information is based on departure data extracted directly from ICAO Digest of Statistics No. 249, 1978.

TABLE I-3

AIR CARRIER FIXED-WING TURBO-JET AIRCRAFT TOTAL U.S. VERSUS NON-U.S. AIRCRAFT  
(MANUFACTURERS AND OPERATORS) WORLD-WIDE MARKET SHARE BY MILLIONS OF DEPARTURES

1979

US Manufacturers

	US Carriers	Non-US Carriers	Total
<u>Boeing</u>	<u>2,782,949</u>	<u>1,282,570</u>	<u>4,065,519</u>
707	201,929	198,140	400,069
720	7,661	66,585	74,246
727	2,029,597	444,762	2,474,359
737	447,534	425,961	873,495
747	96,228	147,122	243,350
<u>Douglas</u>	<u>1,445,458</u>	<u>1,124,287</u>	<u>2,569,745</u>
DC-8	150,192	181,136	331,328
DC-9	1,165,151	845,663	2,010,814
DC-10	130,115	97,488	227,603
<u>Convair</u>	- - - -	9,977	9,977
880	- - - -	320	320
990	- - - -	9,657	9,657
<u>Grumman</u>	- - - -	1,540	1,540
1159	- - - -		
<u>Lockheed</u>	- - - -	- - - -	- - - -
1011	122,379	52,411	174,790
<u>Total</u>	<u>4,350,786</u>	<u>2,470,785</u>	<u>6,821,571</u>

Non-US Manufacturers

<u>BAC-SUD</u>	- - - -	4,027	4,027
Concorde	- - - -		
<u>Dassault</u>	- - - -	19,991	19,991
Mercure	- - - -		
<u>Airbus</u>	11,992	63,913	75,905
300			
<u>Fokker</u>	- - - -	151,050	151,050
F-28	- - - -		
<u>Hawker</u>	- - - -	83,035	83,035
HS-106	- - - -	4,373	4,373
HS-121	- - - -	78,155	78,155
HS-125	- - - -	507	507

1979

Non-US Manufacturers (continued)

	<u>US Carriers</u>	<u>Non-US Carriers</u>	<u>Total</u>
Ilyushin IL-62	- - - -	8,739	8,739
SUD SE-210	- - - -	89,733	89,733
Topolev TV-134	- - - -	28,540	28,540
BAC	104,235	153,852	258,087
I-11	104,235	142,095	246,330
VC-10	- - - -	11,757	11,757
VFW 614	- - - -	5,857	5,857
Yakovlev Yak-40	- - - -	22,801	22,801
<u>Total</u>	116,227	631,538	747,765

1979

	<u>US Carriers</u>		<u>Non-US Carriers</u>		<u>Total</u>
<u>US Manufacturers</u>					
Boeing	2.783	68%	1.283	32%	4.066
Douglas	1.445	56%	1.124	44%	2.569
Convair	- - -		.010		.010
Grumman	- - -		.002		.002
Lockheed	.122	70%	.052	30%	.175
Total	4.350	64%	2.471	36%	6.822

<u>Non-US Manufacturers</u>					
BAC-SUD	- - - -		.004		.004
Dassault	- - - -		.020		.020
Airbus	.012	16%	.064	84%	.076
Fokker	- - - -		.151		.151
Hawker	- - - -		.083		.083
Ilyushin	- - - -		.009		.009
SUD	- - - -		.090		.090
Topolev	- - - -		.028		.028
BAC	.104	40%	.154	60%	.258
VFW	- - - -		.006		.006
Yakovlev	- - - -		.023		.023
<u>Total</u>	<u>.116</u>	<u>16%</u>	<u>.632</u>	<u>84%</u>	<u>.748</u>

Total All Manufacturers/All Carriers : 7.570

Total U.S. Manufacturers Market Share:  $6.822/7.570 = 90\%$

Total US Air Carrier Market Share:  $4.350/7.570 = 57.5\%$

Information is based on departure data taken directly from ICAO Digest of Statistics No. 262, 1979.



## APPENDIX II

### Resumes of U.S. Air Carrier Accidents

The attached resumes are grouped in listings of All Accidents and Fatal Accidents. They are based on a review of the National Transportation Board's (NTSB) accident reports covering the period of January 1, 1977 through December 31, 1979. The resumes utilize the following format:

1. NTSB file number.
2. Date of occurrence.
3. Aircraft make and model.
4. Probable cause(s) as determined by the NTSB.
5. An operational review regarding human factors, crew workload, and flight deck crew size as it relates to the specific accident.

The accidents selected for this review are those involving the following five (5) specific aircraft makes and models:

1. BAC 1-11
2. Boeing 727
3. Boeing 737
4. Douglas DC-8
5. Douglas DC-9

All Accidents

1-0010 7/9/78 BAC 1-11

Overshot runway, collided with ditches.

1-0002 1/25/77 Boeing 727

Collision with aircraft, both on ground. Pilot in command failed to see and avoid other aircraft, taxiways covered with ice/snow.

1-0007 2/11/77 Boeing 727

Turbulence associated with clouds and/or thunderstorms, seat belt sign on.

1-0005 3/4/77 Boeing 727

Turbulence.

1-0022 6/3/77 Boeing 727

Collision with wires/poles during hazardous wind conditions. Pilot in command initiated flight in adverse weather conditions.

1-0024 6/9/77 Boeing 727

Turbulence. Under the jurisdiction of the German government.

1-0001 9/21/77 Boeing 727

Turbulence. Seat belt sign on. Passenger standing in aisle.

1-0008 3/9/78 Boeing 727

Passenger fell down stairs while deplaning.

1-0012 4/19/78 Boeing 727

Turbulence. Seat belt sign on.

1-0006 5/8/78 Boeing 727

Collision with ground/water controlled. Pilot in command and co-pilot failed to follow approved procedure. Descent rate, altitude not monitored, call-outs not provided.

1-0011 5/21/78 Boeing 727

Engine failure or malfunction, turbine assembly retention blade, turbine assembly blade, turbine wheel, engine fire. Panic during evacuation, galley slide failed, passengers jumped off wings.

All Accidents  
Boeing 727's (continued)

1-0014 9/7/78 Boeing 727

Collision with another aircraft. Both on ground.

1-0021 9/25/78 Boeing 727

Collision with aircraft, both in flight. Pilot in command failed to follow approved procedures. Crew did not comply with maintain-visual-separation clearance.

1-0022 10/4/78 Boeing 727

Aircraft static - Ground vehicle struck #2 engine.

2/14/79 Boeing 727

Near collision on ground.

2/15/79 Boeing 727

Gear collapsed.

4/5/79 Boeing 727

Uncontrolled descent.

4/19/79 Boeing 722

Hard landing.

8/7/79 Boeing 727

Wheels up landing.

1-0005 5/30/78 Boeing 737

Turbulence. Pilot in command failed to follow approved procedures. Pilot in command, inadequate supervision of flight. Seat belt sign on. Flight attendant injured while making drinks for cockpit crew.

1-0018 12/21/78 Boeing 737

Turbulence - Flight attendant seat belt not fastened.

2/21/79 Boeing 737

Turbulence.

8/18/79 Boeing 737

Right main gear collapsed due to failure of drag-strut clevis-link pin.

All Accidents (Continued)

1-0010 4/4/77 Douglas DC-9

Collision with ground/water. Controlled compressor stalls. Personnel failure to keep flight properly advised. Pilot in command improper in-flight decisions or planning. Ingestion of massive amounts of water and hail induced stall.

1-0012 8/21/77 Douglas DC-9

While taxiing runway, aircraft hit a parked tug. Failure of pilot in command to see and avoid objects or obstructions.

1-0003 4/5/78 Douglas DC-9

Turbulence. Seat belt sign on.

2/9/79 Douglas DC-9

Loss of control on takeoff.

4/9/79 Douglas DC-9

Turbulence.

4/21/79 Douglas DC-9

Left wing struck runway on landing.

1-0013 1/16/77 Douglas DC-8

Engine failure or malfunction. Compressor assembly disc, compressor rotor. Pilot in command failed to follow approved procedures. Injuries occurred during evacuation.

1-0003 2/21/77 Douglas DC-8

Collided with parked aircraft while being moved to maintenance hangar.

1-0014 8/5/77 Douglas DC-8

Turbulence in-flight, clear air. Seat belt sign on.

1-0016 8/7/77 Douglas DC-8

Turbulence associated with clouds and thunderstorms. Seat belt sign on.

1-0019 10/2/77 Douglas DC-8

All Accidents (Continued)

Taxi to takeoff, takeoff aborted.

1-0021 12/18/77 Douglas DC-8

Collision with ground, incomplete and ambiguous holding clearance. Electrical failure. Personnel issued improper or conflicting instructions. Pilot in command IFR operation.

1-0002 3/28/78 Douglas DC-8

Turbulence. Pilot in command failed to follow approved procedures. Pilot in command improper inflight decisions or planning.

1-0017 /28/78 Douglas DC-8

Engine failure or malfunction. Collision with trees. Pilot in command mismanagement of fuel. Pilot in command diverted attention from operation of aircraft.

5/27/79 Douglas DC-8

Engine fire.

10/14/79 Douglas DC-8

Ground loop-Swerve.

### Fatal Accidents

1-0010

April 4, 1977, New Hope, GA

Douglas DC-9

Probable causes: Overheated. Weather: Hail and thunderstorm, ingestion of massive amounts of water--induced stall. Failure to keep flight properly advised --improper inflight decision or planning.

Entered severe thunderstorm between 14,000 and 17,000 feet. Both engines were damaged. All thrust was lost. Major contributing factors: failure of company's dispatching system to provide crew with up-to-date severe weather conditions. Captain had to rely on airborne weather radar for penetration of thunderstorm areas. FAA's a.r traffic control system for timely dissemination of information -- inadequate.

Southern Airways Flight 242.

Captain flew into rain area thinking that he could find a hole -- but rain got heavier.

Airtraffic control also maintaining contact with TWA flight and an Eastern Airlines flight regarding weather conditions.

After losing both engines, Captain asked to be diverted to Dobbins Air Force Base--after realizing an immediate emergency landing was necessary, asked for closer airport--given vector headings for Cartersville. In the meantime--lost too much altitude, decided to put aircraft down on highway. Hit trees, signs, powerlines, store-gas station, truck and five cars.

"April 3--flight crew had been on duty 6 hours 2 minutes and had flown 3 hours 3 minutes. Had been off duty 8 hours 15 minutes before resuming duty on April 4. On April 4, they had flown 5 hours 24 minutes and had been on duty about 9 hours when the plane had crashed." NTSB report p.8.

"Although the flight crew was preoccupied with trying to restart the engines and with selecting suitable landing areas, the Safety Board concludes that a few words from the flight crew to the flight attendants about the type of landing expected might have enabled the attendants to better prepare the passengers. Had pillows and blankets been distributed and had shoes been worn, some of the passengers' injuries probably would have been less severe and more passengers probably would have been able to escape from the wreckage." p.25.

NTSB Aircraft Accident Report Report #NTSB-AAR-78-3 Washington, D.C.

Of 85 persons aboard, 62 killed, 22 seriously injured, 1 slightly injured.

Fatal Accidents (Continued)

1-0021 December 18, 1977 Cargo plane near Kaysville, Utah, DC-8F

Collision with ground/water -- controlled  
Traffic control personnel issued improper or conflicting instructions.

Departure point - San Francisco, CA  
Last enroute stop Salt Lake City, UT.

Intended destination - Chicago IL.

Incomplete and ambiguous holding clearance.

United Airlines flight 2860  
Crashed into a mountain in the Wasatch Ranch near Kaysville, Utah.  
Three flight crewmembers, the only persons aboard the aircraft were killed.

Electrical system problem during descent to Salt Lake City Airport.

Flight requested and received clearance to leave the approach control frequency for a "little minute." Absent from frequency for about 7-1/2 minutes. During this time, he entered an area of hazardous terrain. Approach controller unable to contact flight. Flight told to make a left turn to avoid treacherous terrain to the right. Fifteen seconds later, told to climb to 8,000 feet (from 6,000). In process of climb, when crashed into a 7,665 foot mountain at 7200 feet.

NTSB says probable cause of accident due to incomplete and ambiguous hold clearance in combination with flight crews failure to adhere to prescribed impairment of communications procedures and prescribed holding procedures. Before flight took off - "... the dispatcher informed the captain that the flight would be dispatched with the aircraft's No. 1 AC electrical generator inoperative . . . However, before the flight crew left the dispatch office, the dispatcher received information that the generator had been repaired, and he passed this information to the captain." p.2

"According to United Airlines' records, the Captain's most recent trips into Salt Lake City were on January 7 and January 9, 1977. ... The First Officer's most recent trip into Salt Lake City was on November 28, 1976. During 1976 and 1977, the Second Officer had made one trip into Salt Lake City; that trip was on February 26, 1977. p.6

NTSB "Aircraft Accident Report" United Airlines, Inc. Douglas DC-8-57, near Kaysville, Utah, December 18, 1977.

Fatal Accidents (Continued)

1-0006      May 8, 1978      Pensacola, FL      National Airlines B-727-235

Pilot in command failed to follow approved procedures, directives.  
Same for Co-pilot.

Instruments misread or failed to read. Foggy conditions - visibility  
of 4 miles or less.

Descent rate, altitude not monitored. Callouts not provided. Advance  
notice of start descent point not given.

Probable cause "flight crew's unprofessionally conducted nonprecision  
instrument approach, in that the Captain and the crew failed to monitor  
the descent rate and altitude, and the First Officer failed to provide  
the Captain with required altitude and approach performance callouts.  
The crew failed to check and utilize all instruments available for alt-  
itude awareness, turned off the ground proximity warning system and  
failed to configure the aircraft properly and in a timely manner for  
the approach." p.1.

NTSB Aircraft Accident Report      Escambia Bay      Pensacola, FL

52 passengers, 6 crewmembers.

3 fatalities, 15 injured.

"As 2109: 20, National 193 established radio communications with the  
Pensacola radar controller, who told the flight crew that they would be  
vectored for an airport surveillance radar approach to "runway two  
five, wind one nine zero at eight, and altimeter two niner niner four  
(29.94 in Hg).

Came to rest in 12 feet of water.

"Since by regulation, the Mobile to Pensacola position of the flight  
was not an extended overwater flight, the passenger briefing did not  
include the location and use of water survival equipment." p.11.

Tug boat and barge in water, 200-300 yards from aircraft, assisted in  
rescue operation.

1-0021      September 25, 1978      San Diego, CA      B-727-214

Collision with aircraft: Both in flight.

Pilot in command failed to follow approved procedures, directive. Crew  
did not comply with maintained visual separation clearance.

Pacific Southwest Airlines, Inc.

Other aircraft involved: Gibbs Flite Center, Inc. Cessna 172.

Location of accident: 3 miles NE of Lindbergh Field.



Fatal Accidents (Continued)

1-0021 (Continued)

Cessna climbing. Flight 182 making visual approach to runway at Lindbergh Field. Had been advised about the location of the Cessna by the approach controller. Flight crew said had traffic in sight and was instructed to maintain visual separation. Contacted tower--flight crew did not have Cessna in sight -- thought they had passed it.

Probable cause -- failure of flight crew to maintain visual separation clearance and telling the controller that they no longer had the plane in sight. . .

Both occupants of Cessna were killed. 135 persons on board B-727 -- 128 passengers, 7 crewmembers, 7 persons on ground.

1-0017      December 28, 1978      Portland, Oregon      DC-8

From New York, New York to Denver, Colorado.

Inflight holding-landing roll  
Engine failure or malfunction  
Collided with trees

Pilot in command-mismanagement of fuel-diverted attention from operation of aircraft. Fuel exhaustion.

Co-pilot mismanagement of fuel.

Other crewmembers failed to convey concern about fuel supply.

## APPENDIX III

### Departure Data and Accident Data Charts

1977-1979

The accidents selected for this review are those involving the following aircraft makes and models:

1. BAC 1-11
2. Boeing 727
3. Boeing 737
4. Douglas DC-8
5. Douglas DC-9

To be included in the tabulation, these aircraft must have been operated by those operators defined as U.S. Certificated Route Carriers by the Civil Aeronautics Board (CAB). The departure data for the Certificated Route Carriers were extracted directly from the CAB publication "Airport Activity Statistics of Certificated Route Air Carriers."

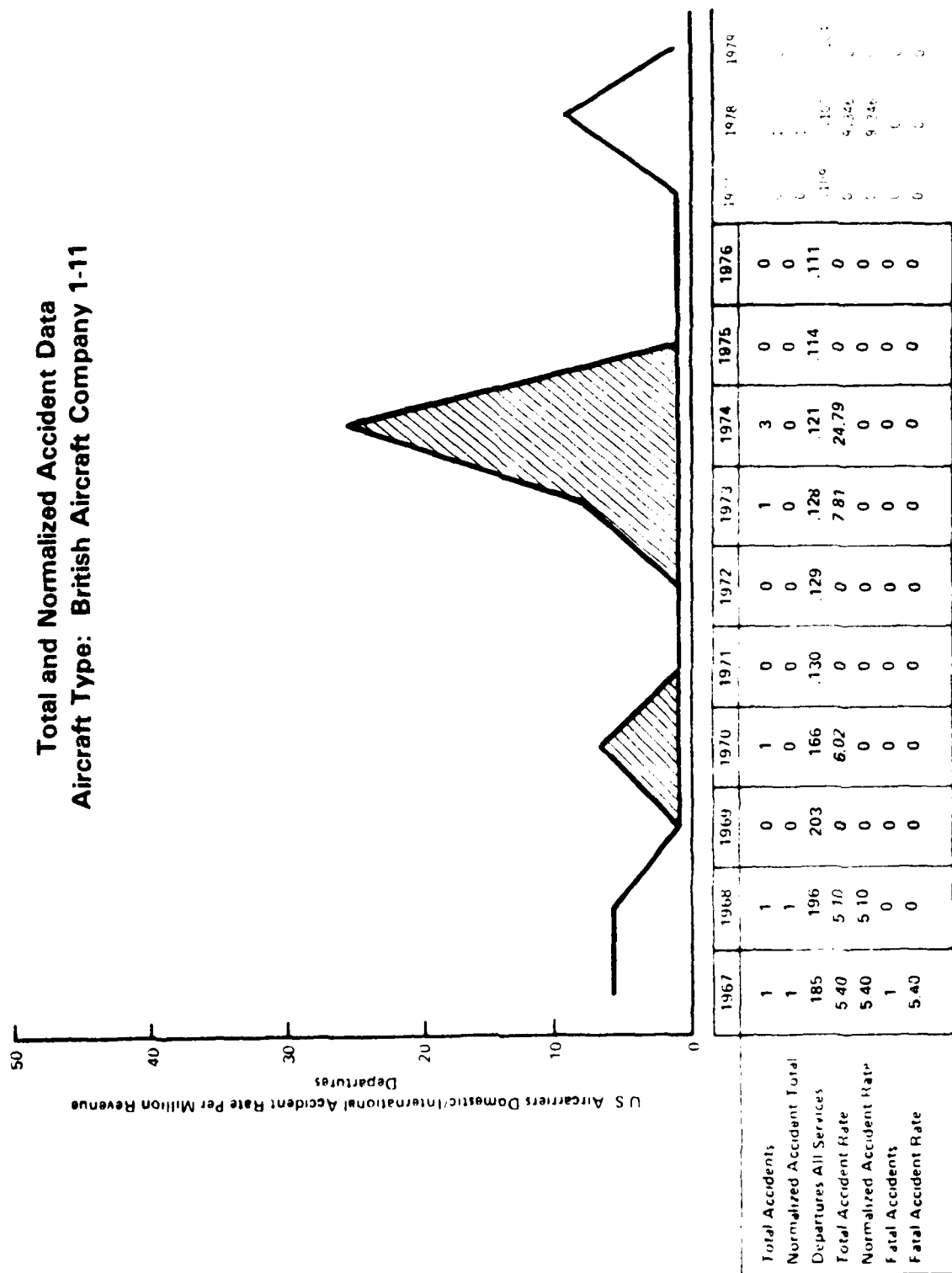
The departure data for three air carriers that did not report to the CAB -- Air California, Southwest, and Air Florida -- were obtained directly from the management of the respective airlines.

The aircraft accidents that were removed from rate consideration in the normalization process are identified on the pages immediately following the table listing the total and normalized accident data for the type aircraft involved.

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Table III-1

**Total and Normalized Accident Data  
Aircraft Type: British Aircraft Company 1-11**



Accident Data Extracted Directly from NTSB Annual Reports    Departure Data Taken Directly from CAB    Airport Activity  
Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines.

Table III-2

**Fatal Accident Data**  
**Aircraft Type: British Aircraft Company 1-11**

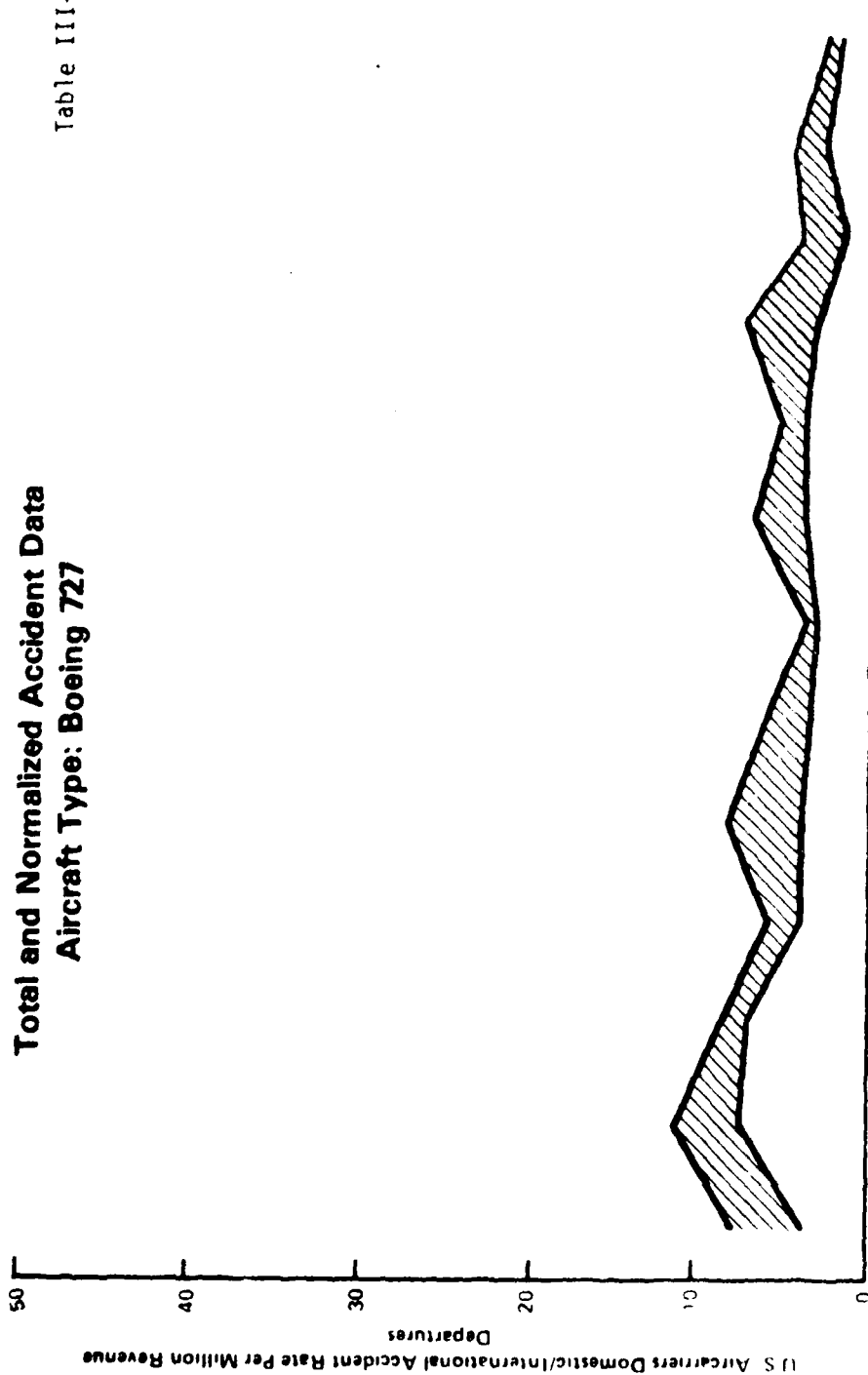
U.S. Airlines Domestic/International Accident Rate Per Million Revenue  
 Departures

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
Total Accidents	1	1	0	1	0	0	1	3	0	0	0	1	0	1
Normalized Accident Total	1	1	0	0	0	0	0	0	0	0	0	1	0	1
Departures All Services	.185	.196	.203	.166	.130	.129	.128	.121	.114	.111	.105	.105	.112	.125
Total Accident Rate	5.40	5.10	0	6.02	0	0	7.81	24.79	0	0	0	9.34e	0	4.40
Normalized Accident Rate	5.40	5.10	0	0	0	0	0	0	0	0	0	9.34e	0	4.40
Fatal Accidents	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Fatal Accident Rate	5.40	0	0	0	0	0	0	0	0	0	0	0	0	.51e

Accident Data Extracted Directly from NTSB Annual Reports    Departure Data Taken Directly from CAB    Airport Activity  
 Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines

# Total and Normalized Accident Data Aircraft Type: Boeing 727

Table III-3



III-4

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
Total Accidents	6	12	11	7	10	8	5	9	7	11	6	7	5	104
Normalized Accident Total	3	8	9	5	5	5	4	5	6	4	2	4	4	64
Departures All Services	820	1105	1286	1287	1308	1378	1495	1480	1550	1677	1777	1842	2121	19,121
Total Accident Rate	7.32	10.86	8.55	5.44	7.64	5.80	3.34	6.08	4.52	6.56	3.38	3.87	2.38	5.42
Normalized Accident Rate	3.66	7.24	7.00	3.88	3.82	3.63	2.66	3.38	3.87	2.38	1.19	2.112	1.19	3.112
Fatal Accidents	1	0	2	1	1	0	0	2	1	2	0	2	2	17
Fatal Accident Rate	123	0	155	0.78	0.76	0	0	1.35	0.64	1.19	0	1.056	0	16.1

Accident Data Extracted Directly from NTSB Annual Reports. Departure Data Taken Directly from CAB. Airport Activity Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines.

THESE BOEING 727 ACCIDENTS WERE REMOVED FROM RATE  
CONSIDERATION IN THE NORMALIZATION PROCESS.

1-0007 2/11/77 B-727

Turbulence, seat belt sign on.

1-0005 3/4/77 B-727

Turbulence associated with clouds and/or thunderstorms, seat belt sign on.

1-0024 6/9/77 B-727

Turbulence. Under the jurisdiction of the German government.

1-0001 9/21/77 B-727

Turbulence. Seat belt sign on. PAX standing in aisle.

1-0008 3/9/78 B-727

PAX fell down air stairs while deplaning.

1-0012 5/8/78 B-727

Turbulence. Seat belt sign on.

1-0022 10/4/78 B-727

Fire truck struck standing aircraft. Truck driver unfamiliar with vehicle.

2/14/79 B-727

Near collision on ground.

Table III-4

Fatal Accident Data  
Aircraft Type: Boeing 727

U.S. Air Carriers Domestic/International Accident Rate Per Million Revenue  
Departures

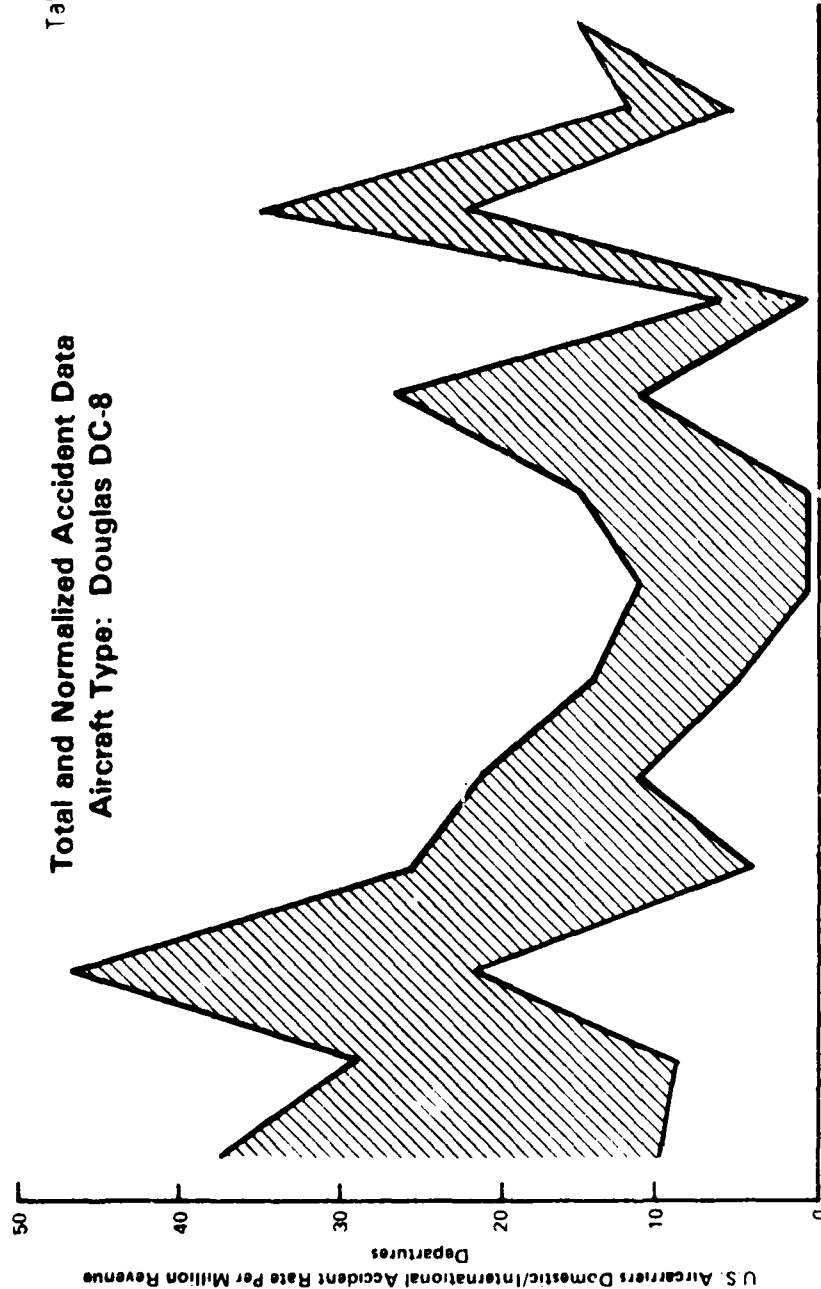
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Total Accidents	6	12	11	7	10	8	5	9	7	11	6	7	5	104
Normalized Accident Rate	3	8	9	5	5	5	4	5	6	4	2	4	4	64
Departures (Millions)	822	1,195	1,286	1,297	1,308	1,378	1,435	1,489	1,559	1,672	1,678	1,678	1,678	1,678
Total Accident Rate	7.32	10.86	8.55	5.44	7.64	5.80	3.34	6.08	4.52	6.58	3.52	4.16	2.39	38.7
Normalized Accident Rate	1.85	7.24	7.00	2.83	3.82	3.63	2.66	3.38	3.67	2.38	1.10	2.44	1.88	23.8
Fatal Accidents	1	0	2	1	1	0	0	2	1	2	0	0	0	0
Fatal Accident Rate	1.23	0	1.55	0.78	0.75	0	0	1.35	0.64	1.19	0	1.05	0	0

Accident Data Extracted Directly from NTSB Annual Reports

Statistics of Certified Route Air Carriers and Certification from Air California and Southwest Airlines

Table III-5

# Total and Normalized Accident Data Aircraft Type: Douglas DC-8



	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
Total Accidents	8	7	13	8	6	4	3	3	5	1	6	2	2	68
Normalized Accident Total	2	2	6	2	3	2	0	0	2	0	4	1	2	26
Departures All Services	217	240	277	282	294	299	280	210	194	180	171	154	133	2,935
Total Accident Rate	36.87	29.16	46.93	28.36	20.41	13.38	10.71	14.28	25.77	5.55	35.088	12.658	15.037	23.169
Normalized Accident Rate	9.22	8.33	21.66	7.09	10.20	6.69	0	0	10.31	0	23.392	6.324	15.037	8.864
Fatal Accidents	1	0	0	1	0	1	1	0	0	0	1	1	0	6
Fatal Accident Rate	4.61	0	0	3.55	0	3.34	3.57	0	0	0	5.848	6.329	0	2.046

Accident Data Extracted Directly from NTSB Annual Reports. Departure Data Taken Directly from CAB. Airport Activity Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines.



THESE McDONNELL DOUGLAS DC-8 ACCIDENTS WERE REMOVED FROM  
RATE CONSIDERATION IN THE NORMALIZATION PROCESS.

1-0014 8/5/77 DC-8

Turbulence in flight, clear air. Seat belt sign on.

1-0016 8/7/77 DC-8

Turbulence associated with clouds and thunderstorms. Seat belt sign on.

1-0002 3/28/78 DC-8

Type of accident: Turbulence.

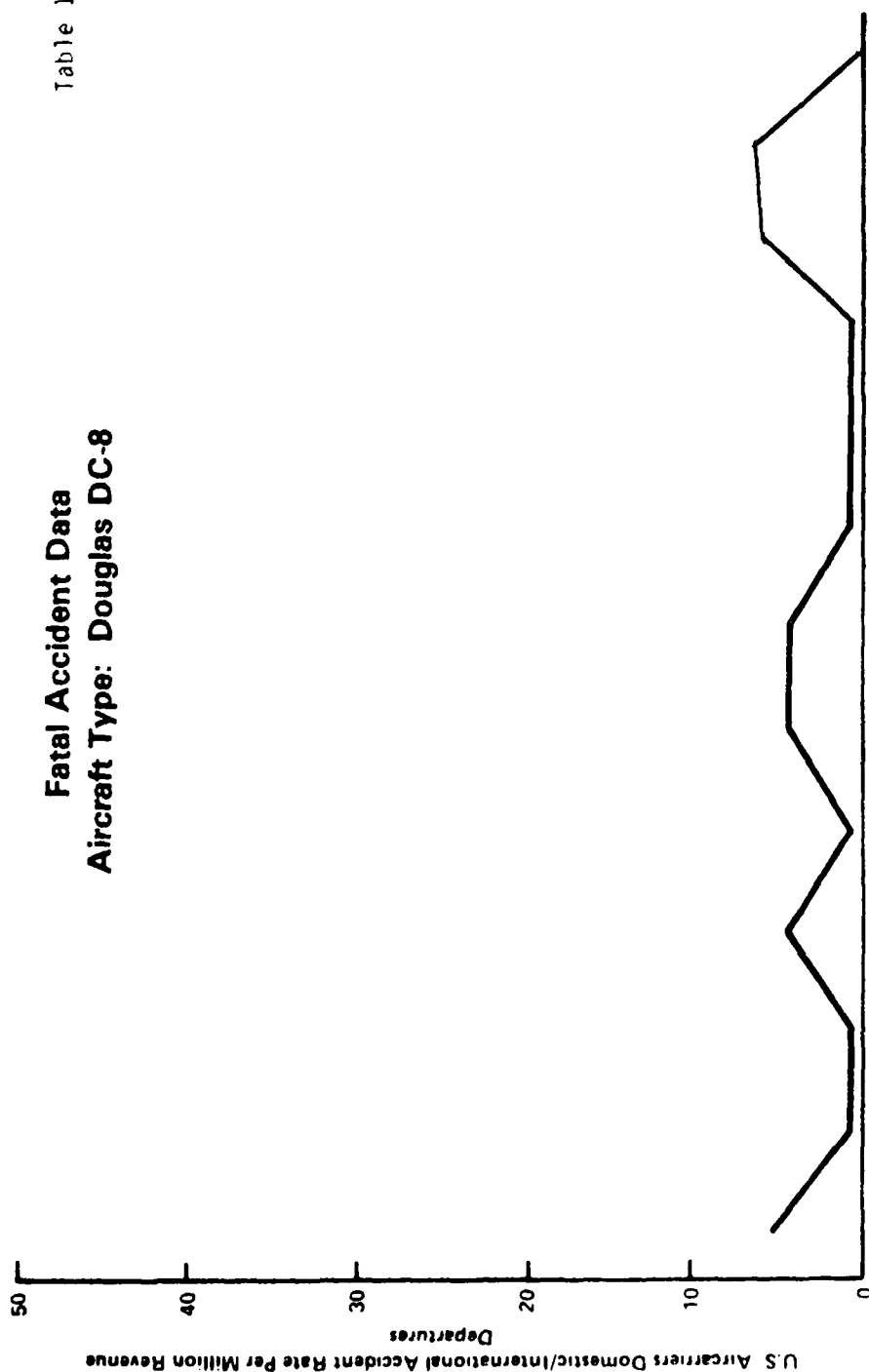
Probable cause(s):

Pilot in command -- Failed to follow approved procedures, directives, etc.

Pilot in command -- Improper in-flight decisions or planning.

Table III-6

# Fatal Accident Data Aircraft Type: Douglas DC-8

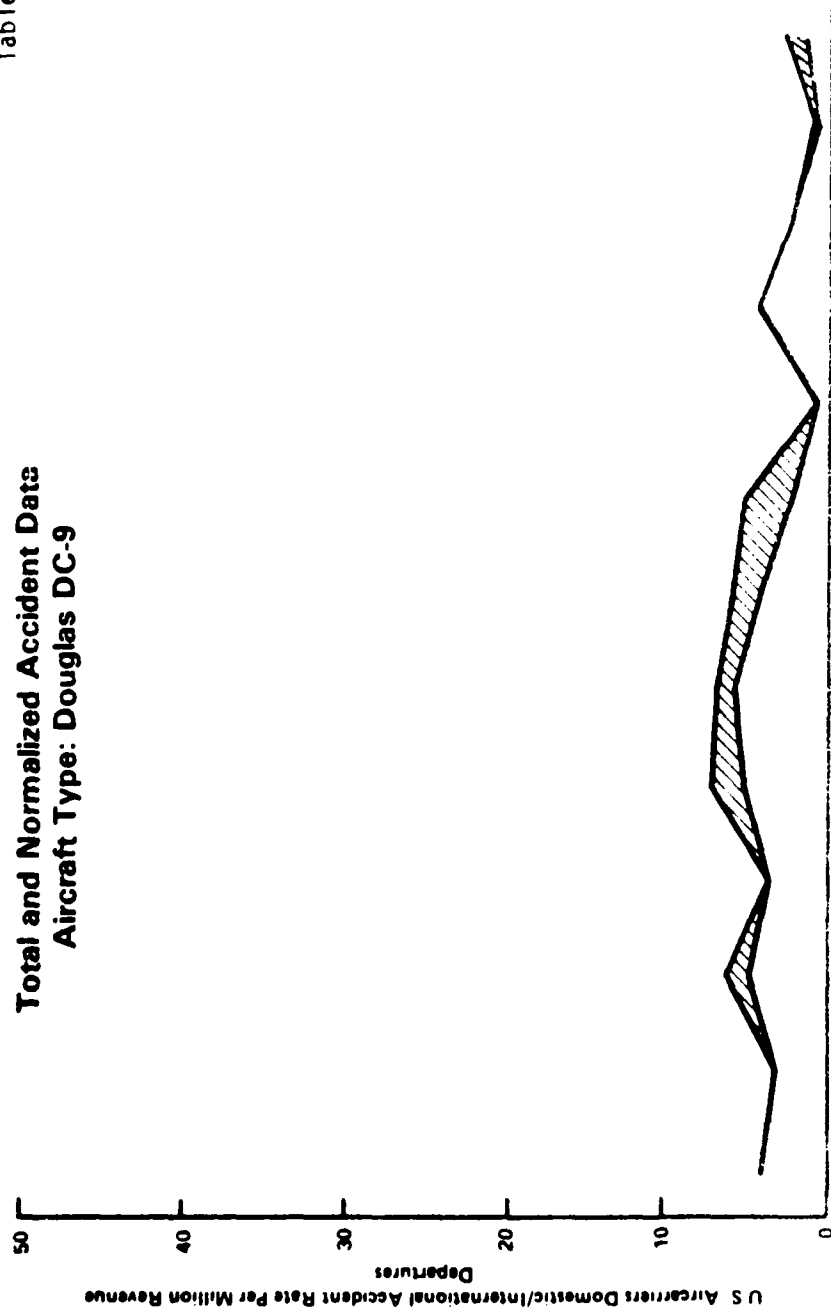


	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
Total Accidents	8	7	13	8	6	4	3	3	5	1	6	2	2	68
Normalized Accident Total	2	2	6	2	3	2	0	0	2	0	4	1	2	26
Departures All Services	.217	.240	.277	.282	.294	.299	.280	.210	.194	.180	.171	.158	.133	2.935
Total Accident Rate	36.87	29.16	46.93	28.36	20.41	13.38	10.71	14.28	25.77	5.55	35.06	12.64	15.03	23.16
Normalized Accident Rate	9.22	8.33	21.66	7.09	10.20	6.69	0	0	10.31	0	23.39	6.32	15.02	41.54
Fatal Accidents	1	0	0	1	0	1	1	0	0	0	1	1	0	6
Fatal Accident Rate	4.61	0	0	3.55	0	3.34	3.57	0	0	0	5.84	6.32	0	2.044

Accident Data Extracted Directly from NTSB Annual Reports Departure Data Taken Directly from CAB Airport Activity  
Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines

Table III-7

# Total and Normalized Accident Data Aircraft Type: Douglas DC-9



	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
Total Accidents	1	2	6	3	7	7	6	5	4	0	2	1	2	47
Normalized Accident Total	1	2	5	3	5	6	4	2	4	0	2	1	2	36
Departures All Services	313	710	1,018	1,099	1,139	1,166	1,161	1,114	1,176	1,107	1,077	1,046	1,017	13,632
Total Accident Rate	3.13	2.92	5.89	2.73	6.15	6.00	5.17	4.49	3.41	0	1.863	1.94	2.51	3.41
Normalized Accident Rate	3.13	2.92	4.91	2.73	4.39	5.15	3.44	1.79	3.41	0	1.664	0	1.714	2.644
Fatal Accidents	1	1	1	1	3	2	1	1	0	0	1	0	0	12
Fatal Accident Rate	3.13	1.41	0.98	0.91	2.63	1.71	0.86	0.90	0	0	.917	0	0	.881

Accident Data Extracted Directly from NTSB Annual Reports: Departure Data Taken Directly from CAB - Airport Activity  
Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines

THESE McDONNELL DOUGLAS DC-9 ACCIDENTS WERE REMOVED FROM  
RATE CONSIDERATION IN THE NORMALIZATION PROCESS.

1-0003 4/5/78 DC-9

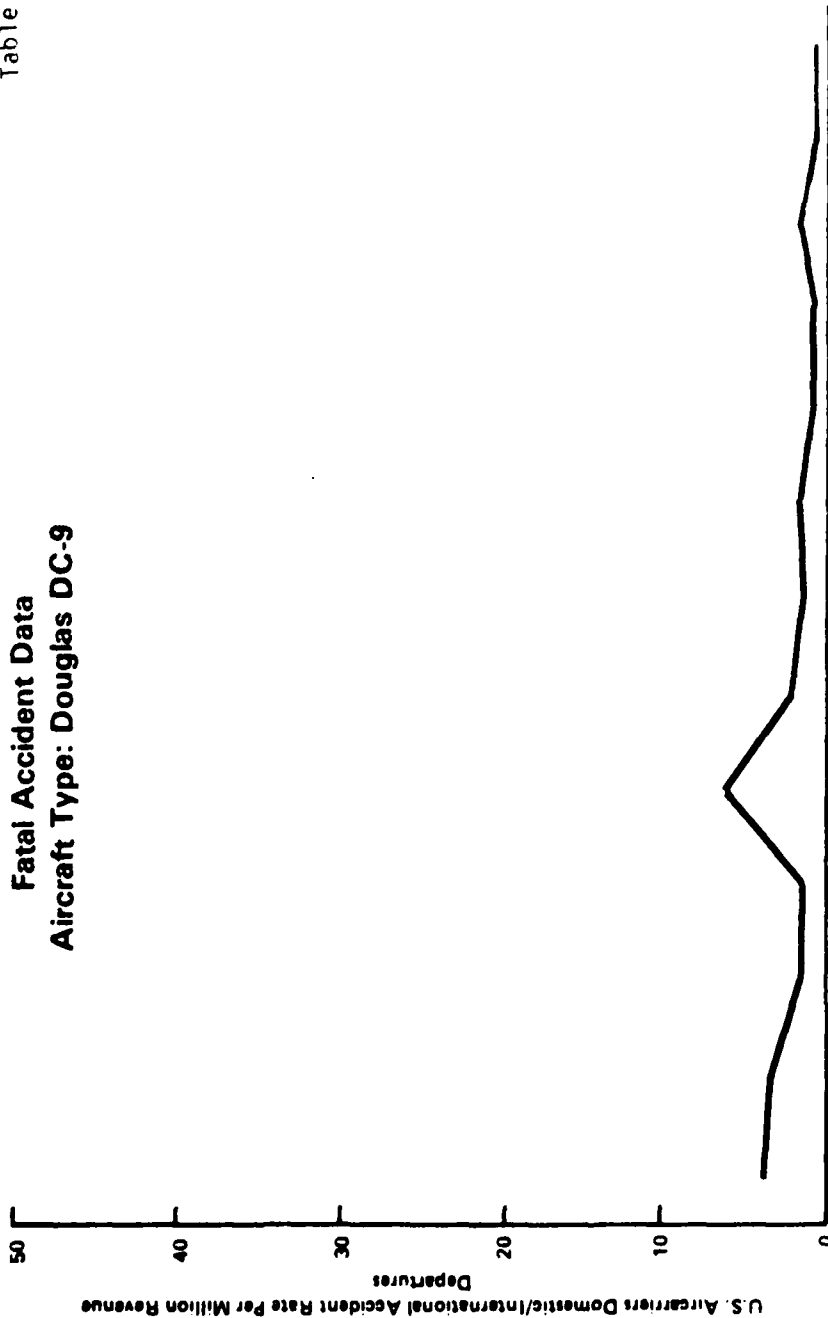
Turbulence. Seat belt sign on.

4/9/79 DC-9

Turbulence.

Table III-8

# Fatal Accident Data Aircraft Type: Douglas DC-9

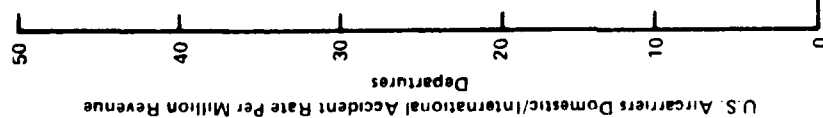


	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
Total Accidents	1	2	6	3	7	7	6	5	0	4	2	1	3	47
Normalized Accident Total	1	2	5	3	5	6	4	2	0	4	2	0	2	36
Departures All Services	.319	.710	1.018	1.099	1.139	1.166	1.161	1.114	1.107	1.174	1.202	1.240	1.167	13.616
Total Accident Rate	3.13	2.92	5.89	2.73	6.15	6.00	5.17	4.49	0	3.41	1.664	.806	2.571	3.452
Normalized Accident Rate	3.13	2.92	4.91	2.73	4.38	5.15	3.44	1.79	0	3.41	1.664	0	1.714	2.644
Fatal Accidents	1	1	1	1	3	2	1	1	0	0	1	0	0	12
Fatal Accident Rate	3.13	1.41	0.98	0.91	2.63	1.71	0.86	0.90	0	0	.832	0	0	.881

Accident Data Extracted Directly from NTSB Annual Reports Departure Data Taken Directly from CAB- Airport Activity  
Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines.

Table III-9

# Total and Normalized Accident Data Aircraft Type: Boeing 737



	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
Total Accidents	1	1	0	1	1	1	5	0	1	0	0	0	0	12
Normalized Accident Total	1	1	0	1	1	1	3	0	1	0	0	0	0	12
Departures All Services	0.079	0.079	0.325	0.374	0.373	0.393	4.20	0.410	0.405	4.33	4.72	5.55	5.55	4.72
Total Accident Rate	12.66	12.66	0	2.67	2.68	2.54	11.88	0	2.47	0	0	3.90	5.55	4.72
Normalized Accident Rate	12.66	12.66	0	2.67	2.68	2.54	7.13	0	2.47	0	0	3.90	5.55	4.72
Fatal Accidents	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Fatal Accident Rate	0	0	0	0	0	2.54	0	0	0	0	0	0	0	0.83

Accident Data Extracted Directly from NTSB Annual Reports. Departure Data Taken Directly from CAB. Airport Activity Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines.

THESE BOEING 737 ACCIDENTS WERE REMOVED FROM RATE  
CONSIDERATION IN THE NORMALIZATION PROCESS.

1-0005 5/30/78 B-737

Type of accident: Turbulence.

Probable cause(s): Pilot in Command -- inadequate supervision of flight.  
Flight Attendant -- seat belt not fastened, seat belt  
sign on.

1-0018 12/21/78 B-737

Type of accident: Turbulence.

Probable cause(s): Flight Attendant -- seat belt not fastened, seat belt  
sign on.

2/21/79 B-737

Turbulence.

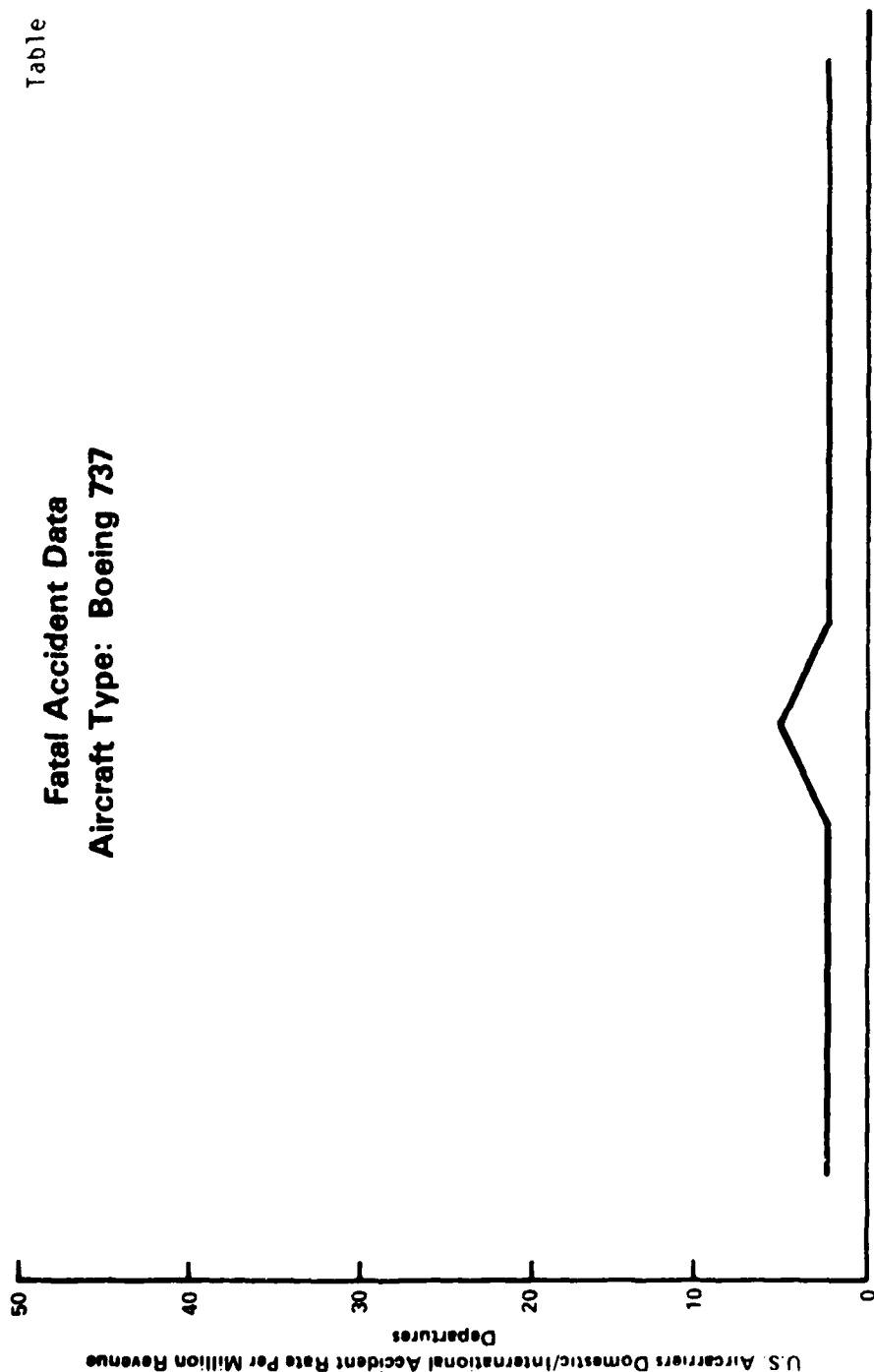
8/18/79 B-737

Right main gear collapsed due to failure of drag strut clevis link pin.

Table III-10

# Fatal Accident Data

## Aircraft Type: Boeing 737



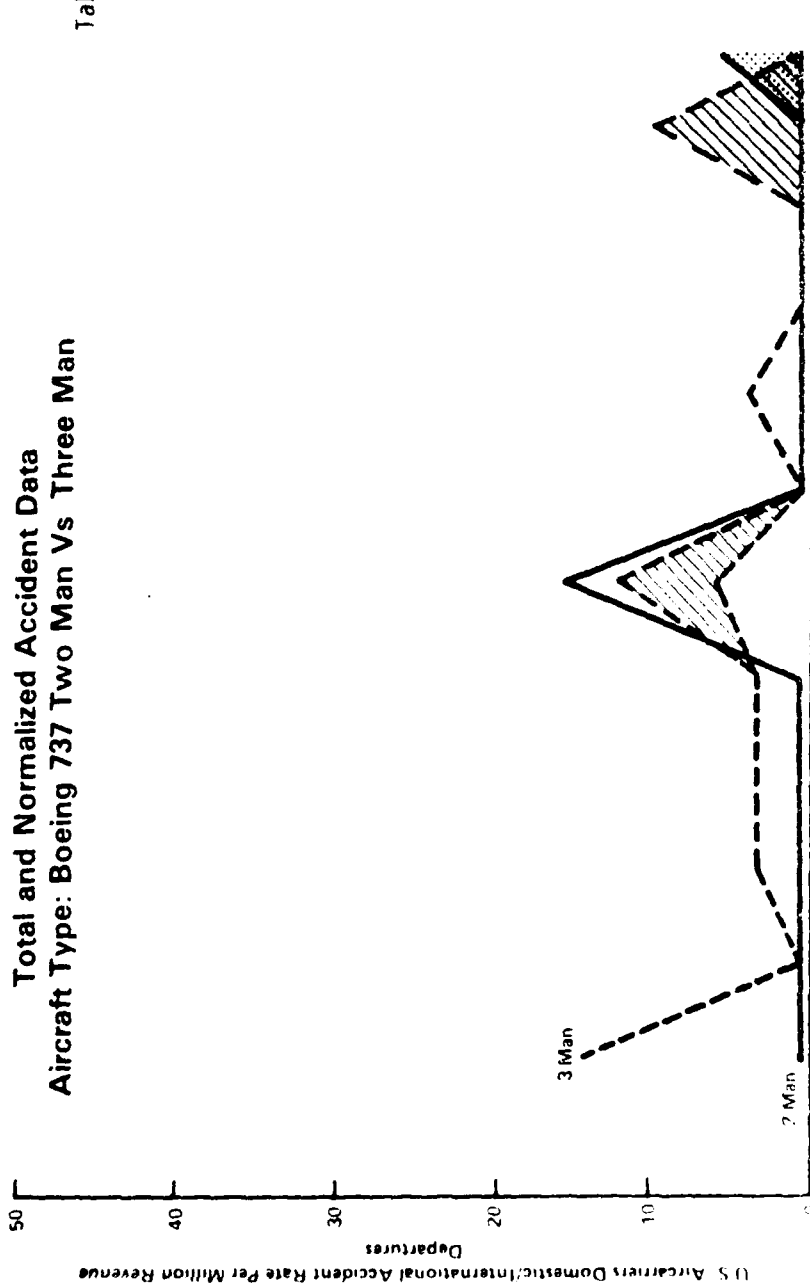
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
Total Accidents	-	1	0	1	1	1	5	0	1	0	0	1	2	14
Normalized Accident Total	-	1	0	1	1	1	3	0	1	0	0	1	1	8
Departures All Services	-	.079	.325	.374	.373	.393	.420	.410	.405	.433	.477	.519	.519	4.74
Total Accident Rate	-	12.66	0	2.67	2.68	2.54	11.88	0	2.47	0	0	2.47	3.454	2.925
Normalized Accident Rate	-	12.66	0	2.67	2.68	2.54	7.13	0	2.47	0	0	2.47	3.454	1.674
Fatal Accidents	-	0	0	0	0	1	0	0	0	0	0	0	1	1
Fatal Accident Rate	-	0	0	0	0	2.54	0	0	0	0	0	0	1	.206

Accident Data Extracted Directly from NTSB Annual Reports. Departure Data Taken Directly from CAB—Airport Activity Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines.



Table III-11

**Total and Normalized Accident Data  
Aircraft Type: Boeing 737 Two Man Vs Three Man**

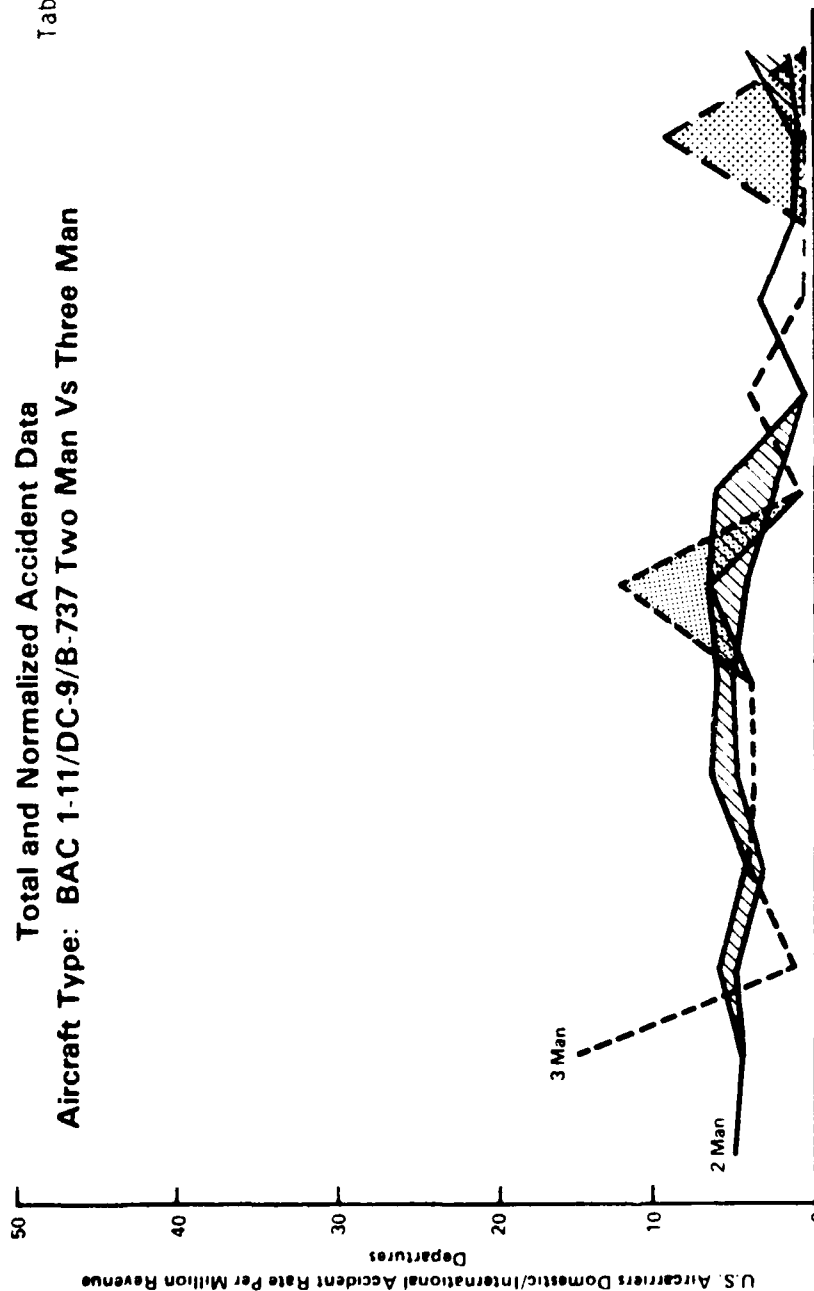


	1968	1969	1970	1971	1972	1973	1974	1975	1976	Total
Total Accidents - 2 Man	0	0	0	0	0	1	0	0	0	1
Departures	006	021	020	033	038	069	139	153	165	1,007
Total Accident Rate	0	0	0	0	0	14.49	0	0	0	1.449
Total Accidents - 3 Man	1	0	1	1	1	4	0	1	0	11
Departures	073	304	354	340	355	351	271	252	268	3,160
Total Accident Rate	13.70	0	2.82	2.94	2.82	11.36	0	3.97	0	9.459
Normalized Acc Rate						5.68				

Accident Data Extracted Directly from FAA Annual Reports. Departure Data Taken Directly from CAB Airport Activity  
 Statistics of Certificated Route Airlines and Certification from Air California and Southwest Airlines

Table III-12

**Total and Normalized Accident Data**  
**Aircraft Type: BAC 1-11/DC-9/B-737 Two Man Vs Three Man**

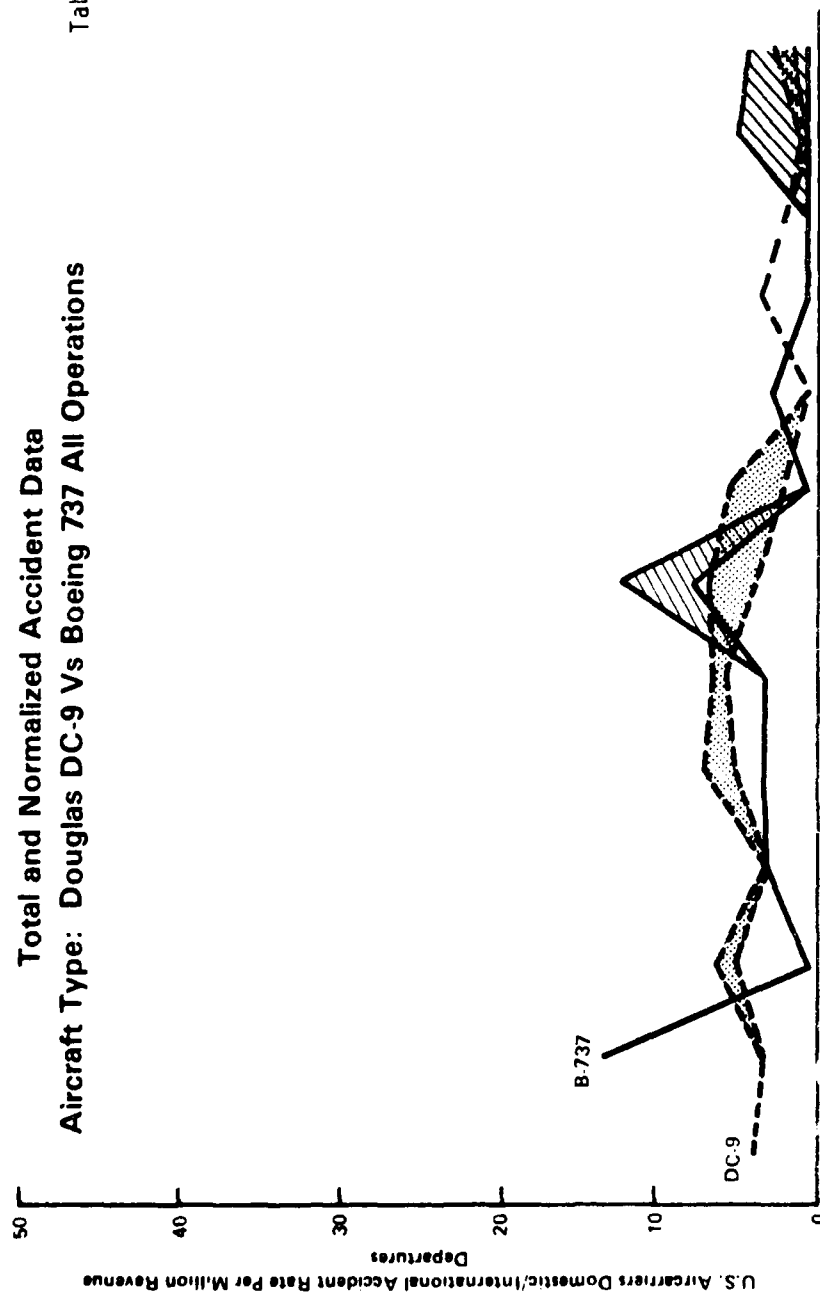


	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Total
Total Accidents - 2 Man	2	3	6	4	7	7	8	8	0	4	2	2	1	1	54
Departures	504	912	1242	1285	1302	1333	1358	1374	1375	1720	1592	1656	1656	1656	17,297
Total Accident Rate	3.97	3.29	4.83	3.11	5.38	5.25	5.89	5.82	0	2.32	1.24	1.21	1.21	1.21	2.02
Normalized Acc Rate	3.97	3.29	4.03	2.33	3.84	4.50	2.58	3.46	0	2.34	1.26	1.21	1.21	1.21	2.02
Total Accidents - 3 Man	1	1	0	1	1	1	4	0	1	0	1	1	1	1	14
Departures	073	304	304	314	310	355	357	271	251	268	2	2	2	2	1,314
Total Accident Rate	13.70	0	0	2.62	2.94	2.67	11.36	0	3.97	0	1	1	1	1	1.2
Normalized Acc Rate	13.70	0	0	2.87	2.94	2.87	5.68	0	3.97	0	1	1	1	1	1.2

Accident Data Extracted Directly from 1976 Annual Report on Air Transportation Safety and Security, Department of Transportation, Office of Civil Aviation, Washington, D.C. 20540  
 Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines

# **Total and Normalized Accident Data** **Aircraft Type: Douglas DC-9 Vs Boeing 737 All Operations**

Table III-13



	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
B 737 - Total Accidents	-	1	0	1	1	1	5	0	1	0	0	2	2	14
Departures	-	079	325	374	373	393	420	410	405	433	472	526	579	4,780
Total Accident Rate	-	12.66	0	2.67	2.68	2.54	11.66	0	2.47	0	0	3.84	3.44	2,924
Normalized Acc. Rate	-	12.66	0	2.67	2.68	2.54	7.13	0	2.47	0	0	0	0	1.674
DC 9 - Total Accidents	1	2	6	3	7	7	6	5	0	4	2	1	2	47
Departures	319	710	1,018	1,099	1,139	1,166	1,161	1,114	1,107	1,174	1,221	1,243	1,157	12,416
Total Accident Rate	3.13	2.92	5.89	2.73	6.15	6.00	5.17	4.49	0	3.41	1.664	1.606	2.571	3,451
Normalized Acc. Rate	3.13	2.92	4.91	2.73	4.39	5.15	3.44	1.79	0	3.41	1.664	0	1.714	2,644

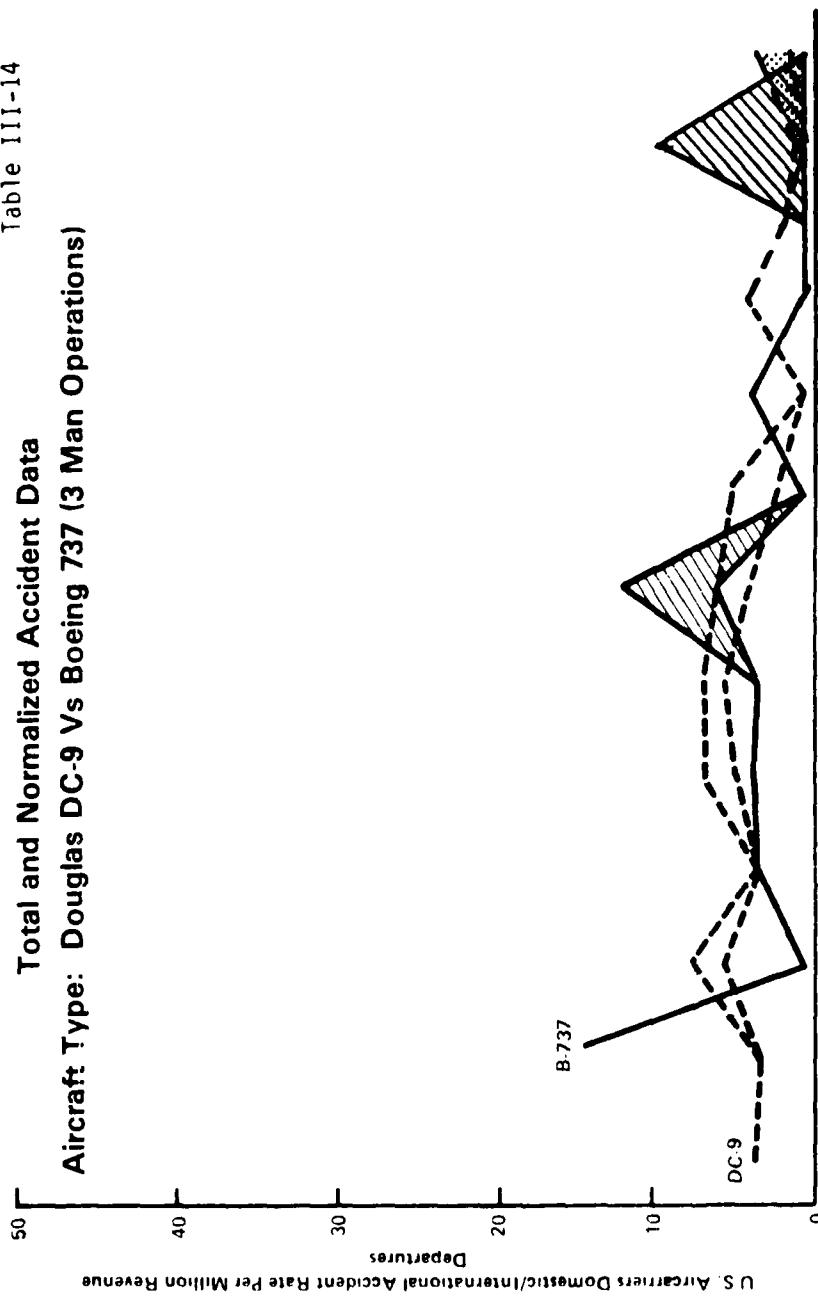
Accident Data Extracted Directly from NTSB Annual Reports. Departure Data Taken Directly from CAB Airport Activity

Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines

Table III-14

## Total and Normalized Accident Data

Aircraft Type: Douglas DC-9 Vs Boeing 737 (3 Man Operations)



	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
B 737 - Total Accidents	-	1	0	1	1	1	4	0	2	0	0	2	0	11
Departures	-	.073	.304	.354	.340	.355	.351	.271	.252	.268	.200	.221	.191	3.180
Total Accident Rate	-	13.70	0	2.82	2.94	2.82	11.36	0	3.97	0	0	9.05	0	3.459
Normalized Acc. Rate	-	13.70	0	2.82	2.94	2.82	5.68	0	3.97	0	0	0	0	2.200
DC-9 - Total Accidents	1	2	6	3	7	7	6	5	0	4	2	1	3	47
Departures	.319	.710	1.018	1.099	1.139	1.166	1.161	1.114	1.107	1.174	1.202	1.240	1.161	13.616
Total Accident Rate	3.13	2.92	5.89	2.73	6.15	6.00	5.17	4.49	0	3.41	1.664	.804	2.571	2.452
Normalized Acc. Rate	3.13	2.92	4.91	2.73	4.39	5.15	3.44	1.79	0	3.41	1.664	0	1.714	2.544

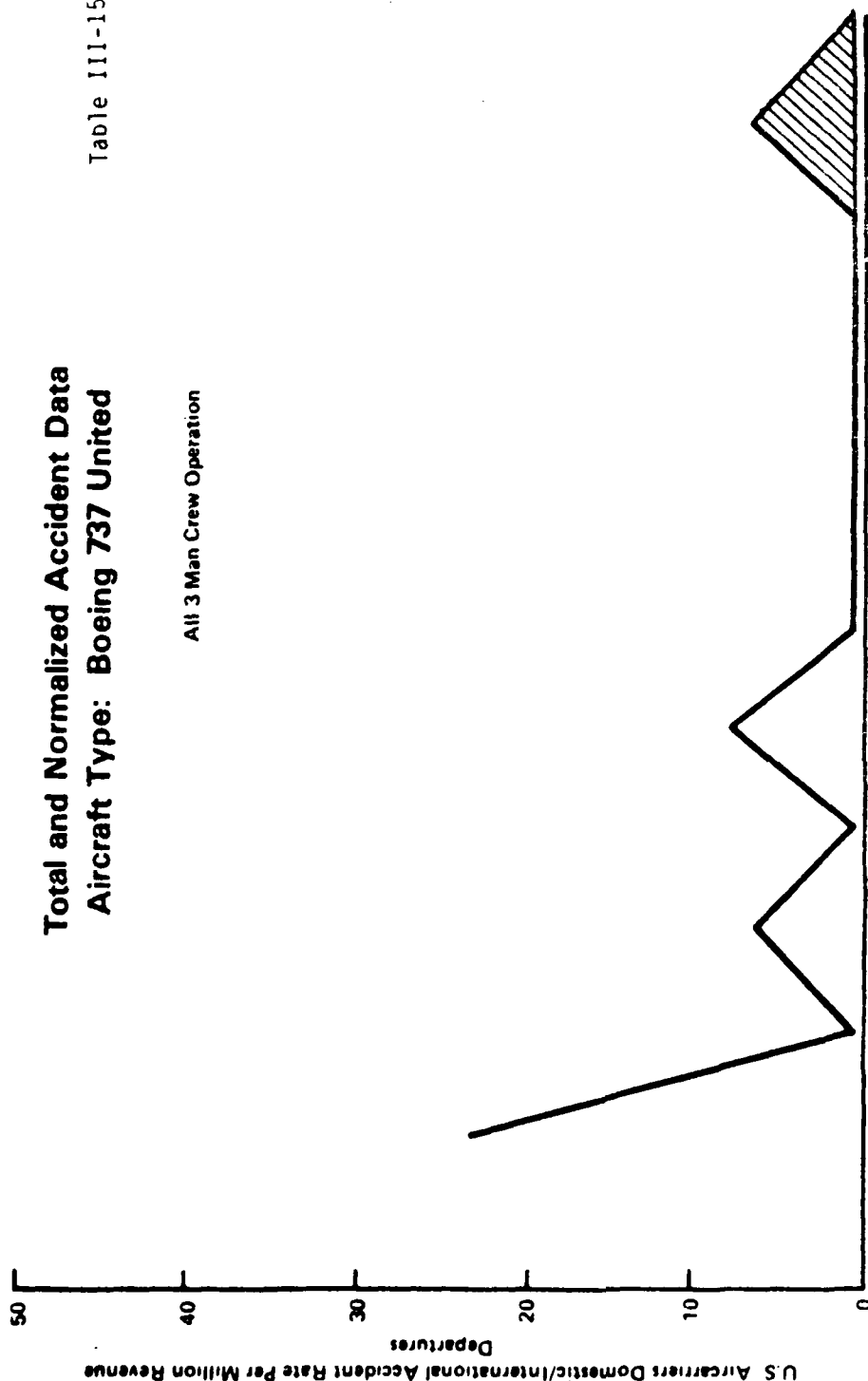
Accident Data Extracted Directly from NTSB Annual Reports. Departure Data Taken Directly from CAB - Airport Activity

Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines.

# Total and Normalized Accident Data Aircraft Type: Boeing 737 United

Table III-15

All 3 Man Crew Operation



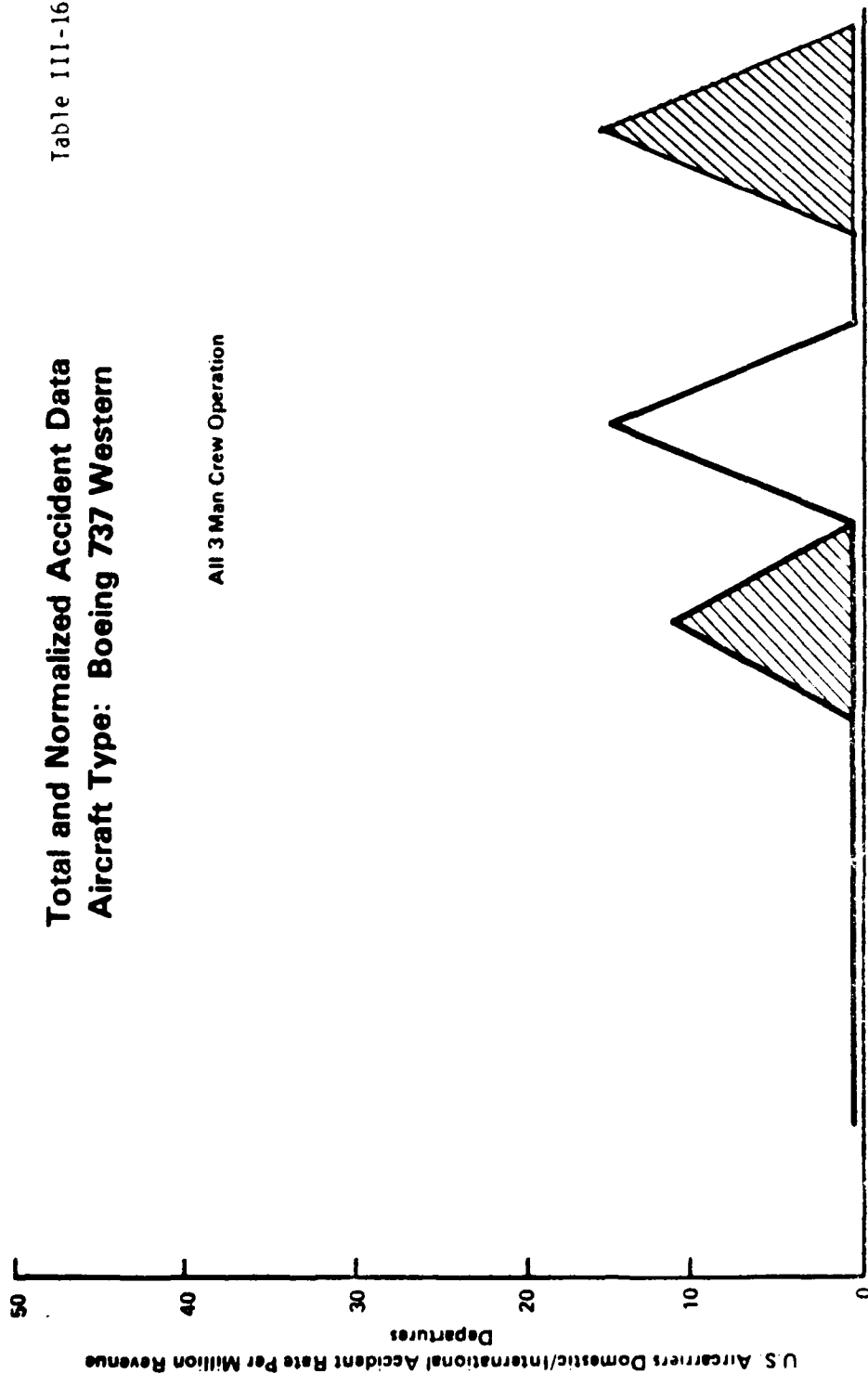
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
Total Accidents	-	1	0	1	0	1	0	0	0	0	0	1	0	4
Normalized Accident Total	-	1	0	1	0	1	0	0	0	0	0	0	0	3
Departures All Services	-	.045	.165	.185	.144	.145	.146	.138	.117	.117	.128	.152	.127	1.609
Total Accident Rate	-	22.73	0	5.43	0	6.94	0	0	0	0	0	6.579	0	2.486
Normalized Accident Rate	-	22.73	0	5.43	0	6.94	0	0	0	0	0	0	0	1.865
Fatal Accidents	-	0	0	0	0	1	0	0	0	0	0	0	0	1
Fatal Accident Rate	-	0	0	0	0	6.94	0	0	0	0	0	0	0	.622

Accident Data Extracted Directly from NTSB Annual Reports Departure Data Taken Directly from CAB- Airport Activity  
Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines

**Total and Normalized Accident Data  
Aircraft Type: Boeing 737 Western**

Table III-16

All 3 Man Crew Operation

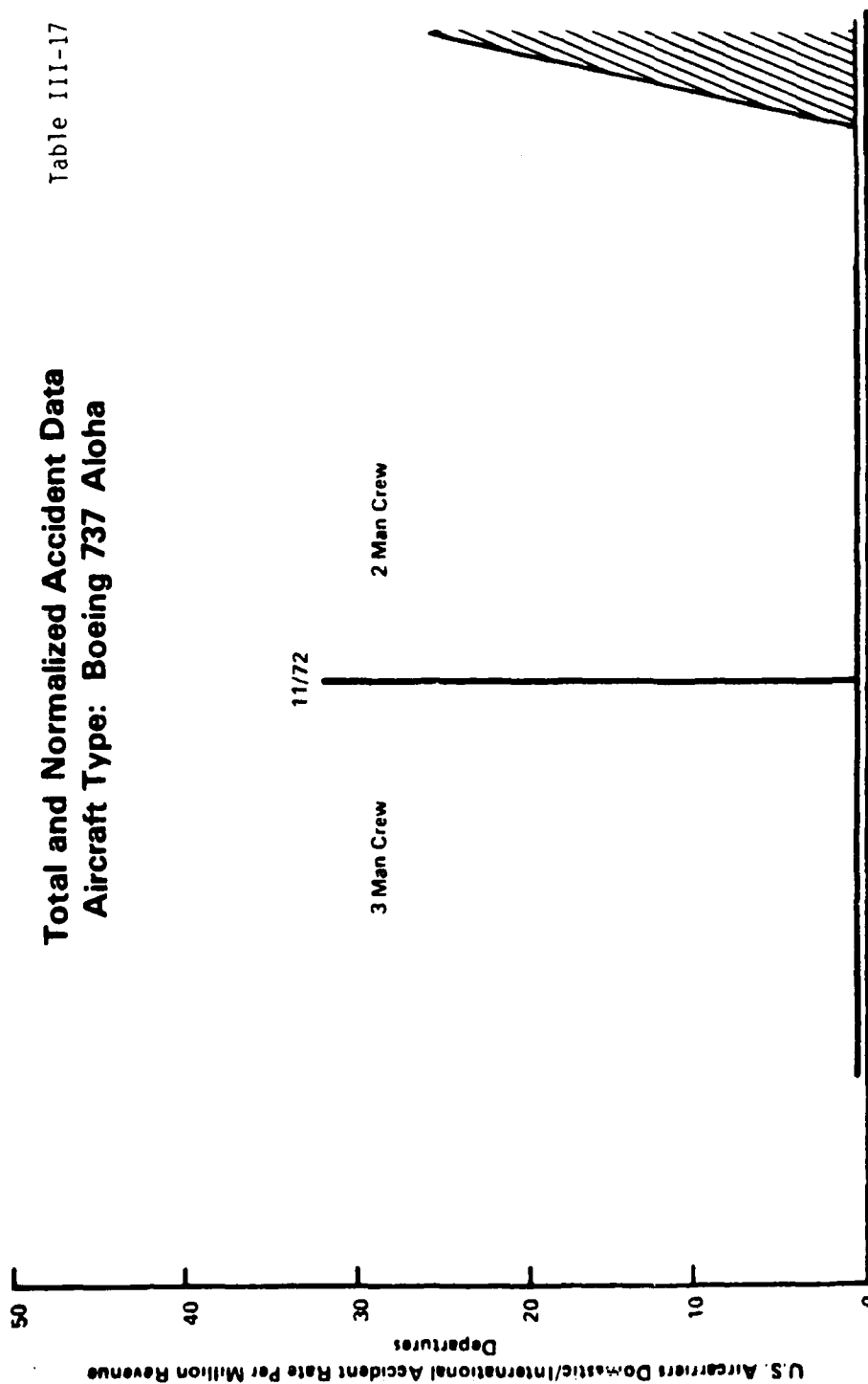


	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
Total Accidents	—	0	0	0	0	0	1	0	1	0	0	1	0	3
Normalized Accident Total	—	0	0	0	0	0	0	0	1	0	0	0	0	1
Departures All Services	—	.019	.076	.081	.088	.090	.091	.079	.071	.072	.072	.069	.064	.871
Total Accident Rate	—	0	0	0	0	0	10.99	0	14.08	0	0	14.003	0	3.450
Normalized Accident Rate	—	0	0	0	0	0	0	0	14.08	0	0	0	0	1.147
Fatal Accidents	—	0	0	0	0	0	0	0	0	0	0	0	0	0
Fatal Accident Rate	—	0	0	0	0	0	0	0	0	0	0	0	0	0

Accident Data Extracted Directly from NTSB Annual Reports. Departure Data Taken Directly from CAB - Airport Activity Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines.

# **Total and Normalized Accident Data Aircraft Type: Boeing 737 Aloha**

Table III-17

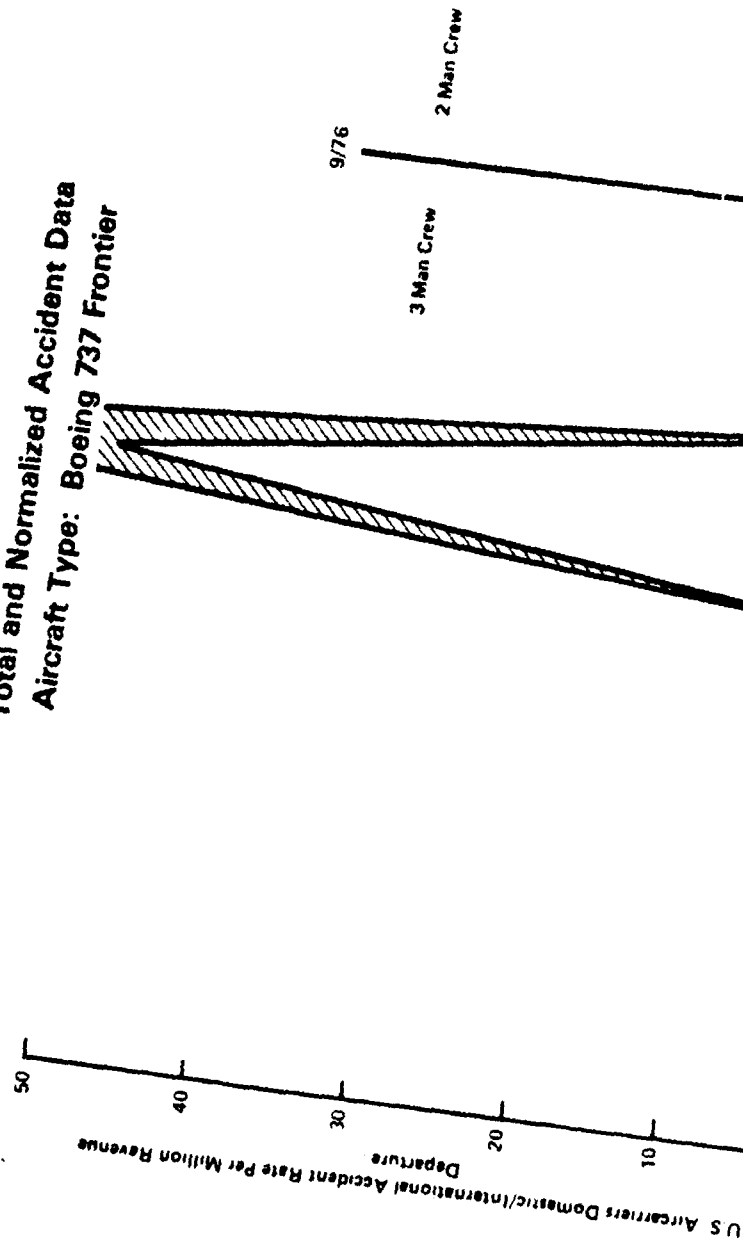


	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
Total Accidents	-	-	0	0	0	0	0	0	0	0	0	0	1	1
Normalized Accident Total	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Departures All Services	-	-	.019	.021	.021	.026	.029	.030	.030	.033	.037	.039	.039	.324
Total Accident Rate	-	-	0	0	0	0	0	0	0	0	0	0	25.641	3.086
Normalized Accident Rate	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Fatal Accidents	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Fatal Accident Rate	-	-	0	0	0	0	0	0	0	0	0	0	0	0

Accident Data Extracted Directly from NTSB Annual Reports. Departure Data Taken Directly from CAB - Airport Activity Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines.

# **Total and Normalized Accident Data** **Aircraft Type: Boeing 737 Frontier**

Table III-18



3 Man Crew  
 2 Man Crew  
 9/76

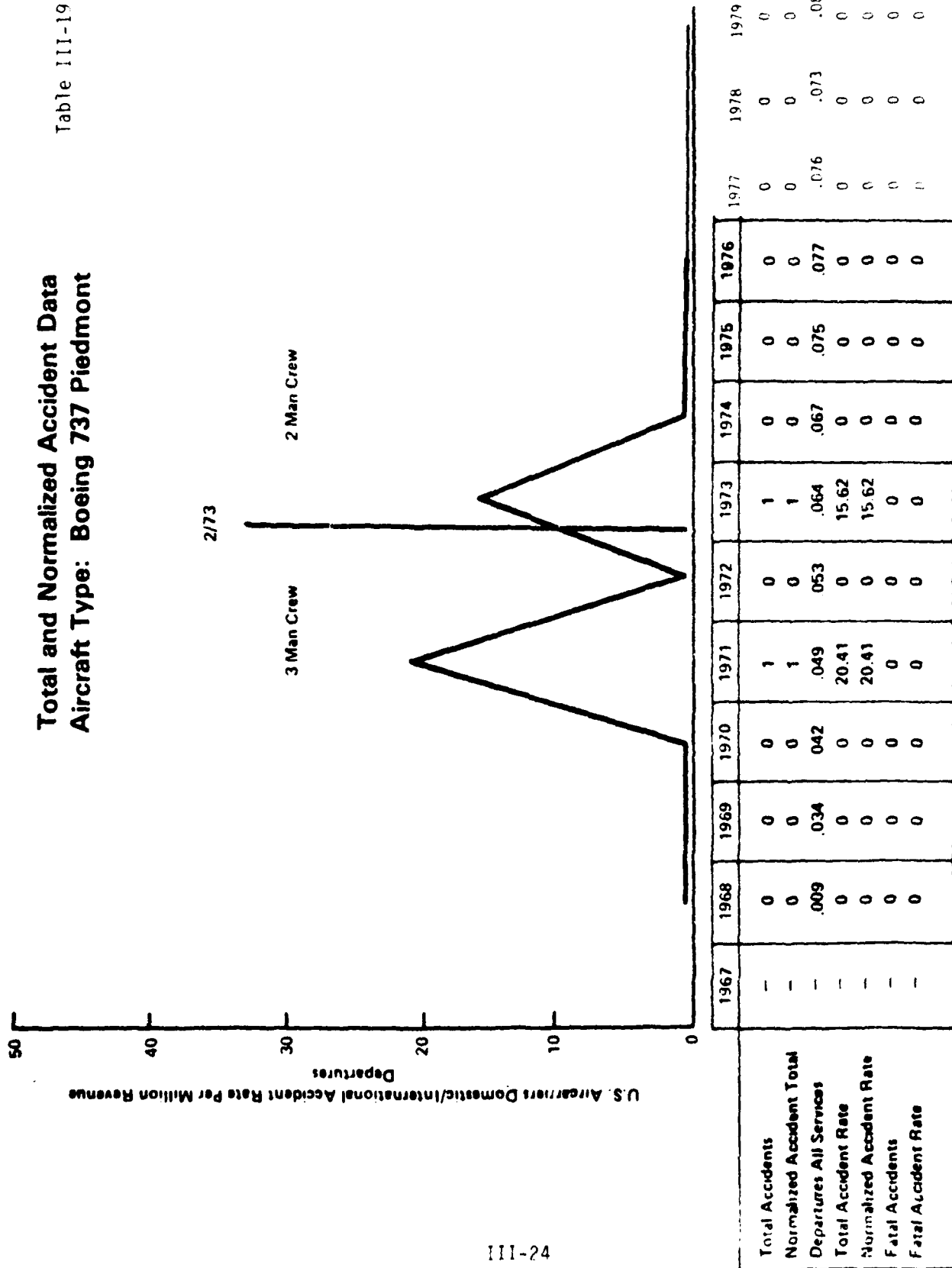
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
Total Accidents	0	0	0	0	0	0	3	0	0	0	0	0	0	3
Normalized Accident Total	0	0	0	0	0	0	2	0	0	0	0	0	0	2
Departure: All Services	0	0	0	0	0	0	0.41	0.45	0.49	0.53	0.53	0.53	0.53	2.42
Total Accident Rate	0	0	0	0	0	0	7.3	7.7	8.0	8.3	8.3	8.3	8.3	32.6
Normalized Accident Rate	0	0	0	0	0	0	48.78	48.78	48.78	48.78	48.78	48.78	48.78	189.6
Fatal Accidents	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fatal Accident Rate	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Accident Data Extracted Directly from NTSB Annual Reports  
 Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines



# **Total and Normalized Accident Data Aircraft Type: Boeing 737 Piedmont**

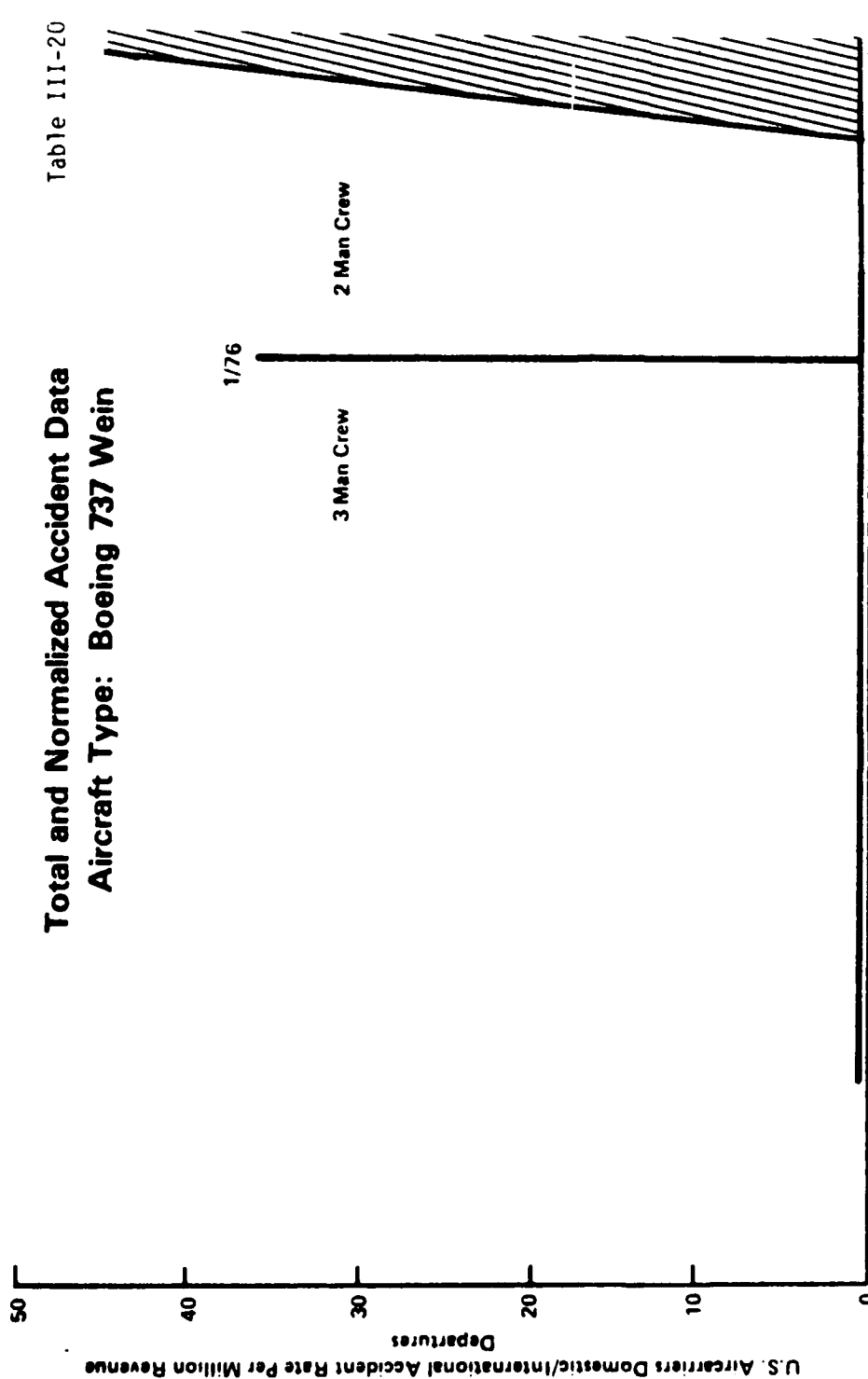
Table III-19



Accident Data Extracted Directly from NTSB Annual Reports. Departure Data Taken Directly from CAB - Airport Activity  
Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines.

Table III-20

# Total and Normalized Accident Data Aircraft Type: Boeing 737 Wein



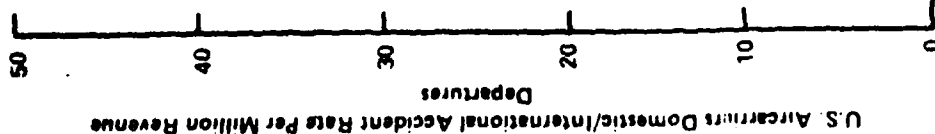
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
Total Accidents	-	-	0	0	0	0	0	0	0	0	0	0	1	1
Normalized Accident Total	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Departures All Services	-	-	.005	.006	.008	.008	.009	.009	.015	.015	.014	.016	.019	.129
Total Accident Rate	-	-	0	0	0	0	0	0	0	0	0	0	52.631	8
Normalized Accident Rate	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Fatal Accidents	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Fatal Accident Rate	-	-	0	0	0	0	0	0	0	0	0	0	0	0

Accident Data Extracted Directly from NTSB Annual Reports. Departure Data Taken Directly from CAB- Airport Activity Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines.

Table 111-21

# Total and Normalized Accident Data Aircraft Type: Boeing 737 Air California

All 2 Man Crew Operation



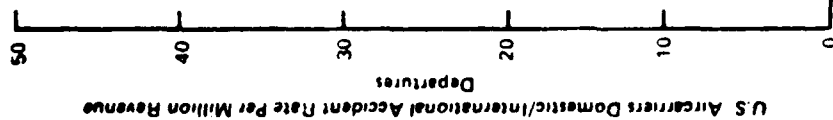
111-26

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	Total
Total Accidents	—	0	0	0	0	0	0	0	0	0	0	0	0
Normalized Accident Total	—	0	0	0	0	0	0	0	0	0	0	0	0
Departures All Services	—	.006	.021	.020	.027	.027	.029	.030	.031	.032	.035	.036	.334
Total Accident Rate	—	0	0	0	0	0	0	0	0	0	0	0	0
Normalized Accident Rate	—	0	0	0	0	0	0	0	0	0	0	0	0
Fatal Accidents	—	0	0	0	0	0	0	0	0	0	0	0	0
Fatal Accident Rate	—	0	0	0	0	0	0	0	0	0	0	0	0

Accident Data Extracted Directly from NTSB Annual Reports. Departure Data Taken Directly from CAB- Airport Activity  
Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines.

Table III-22

**Total and Normalized Accident Data  
Aircraft Type: Boeing 737 Southwest**



	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
Total Accidents	-	-	-	-	0	0	0	0	0	0	0	0	0	0
Normalized Accident Total: Departures All Services	-	-	-	-	0	0	0	0	0	0	0	0	0	0
Total Accident Rate	-	-	-	-	.006	.011	.011	.012	.017	.022	.035	.055	.076	.22
Normalized Accident Rate	-	-	-	-	0	0	0	0	0	0	0	0	0	0
Fatal Accidents	-	-	-	-	0	0	0	0	0	0	0	0	0	0
Fatal Accident Rate	-	-	-	-	0	0	0	0	0	0	0	0	0	0

Accident Data Extracted Directly from NTSB Annual Reports. Departure Data Taken Directly from CAB. Airport Activity Statistics of Certificated Route Air Carriers and Certification from Air California and Southwest Airlines

Table III-23

## Total and Normal Data:

By Aircraft, Air Carrier and Crew Size

BAC 1-11	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
Total Accidents	1	1	0	1	0	0	1	3	0	0	0	1	0	6
Normalized Accident Total	1	1	0	0	0	0	0	0	0	0	0	0	0	3
Departures - All Services	.185	.196	.203	.166	.130	.129	.128	.121	.114	.111	.109	.107	.104	1.822
Total Accident Rate	5.40	5.10	0	6.02	0	0	7.81	24.79	0	0	0	9.346	0	4.437
Normalized Accident Rate	5.40	5.10	0	0	0	0	0	0	0	0	0	9.346	0	1.664
Fatal Accidents	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Fatal Accident Rate	5.40	0	0	0	0	0	0	0	0	0	0	0	0	.555
Boeing 737														
Total Accidents	-	1	0	1	1	1	5	0	1	0	0	2	2	14
Normalized Accident Total	-	1	0	1	1	1	3	0	1	0	0	0	0	8
Departures - All Services	-	.079	.325	.374	.373	.393	.420	.410	.405	.433	.471	.526	.574	4.786
Total Accident Rate	-	12.66	0	2.67	2.68	2.54	11.88	0	2.47	0	0	3.602	3.434	2.924
Normalized Accident Rate	-	12.66	0	2.67	2.68	2.54	7.13	0	2.47	0	0	0	0	1.614
Fatal Accidents	-	0	0	0	0	1	0	0	0	0	0	0	0	1
Fatal Accident Rate	-	0	0	0	0	2.54	0	0	0	0	0	0	0	.209
Two Man Crew Departures														
Total Accidents	-	.006	.021	.020	.033	.038	.069	.139	.153	.165	.270	.305	.394	1.47
Normalized Total Acc.	-	0	0	0	0	0	1	0	0	0	0	0	0	2
Fatal Accidents	-	0	0	0	0	0	1	0	0	0	0	0	0	1
Total Accident Rate	-	0	0	0	0	0	0	0	0	0	0	0	0	0
Norm. Tot. Acc. Rate	-	0	0	0	0	0	14.49	0	0	0	0	0	0	1.003
Fatal Acc. Rate	-	0	0	0	0	0	14.49	0	0	0	0	0	0	.622
Three Man Crew Departures														
Total Accidents	-	.073	.304	.354	.340	.355	.351	.271	.252	.268	.400	.221	.191	3.181
Normalized Total Acc.	-	1	0	1	1	1	4	0	1	0	0	2	0	11
Fatal Accidents	-	1	0	1	1	1	2	0	1	0	0	0	0	7
Total Accident Rate	-	13.70	0	2.82	2.94	2.82	11.36	0	3.96	0	0	9.134	0	2.440
Norm Tot. Acc. Rate	-	13.70	0	2.82	2.94	2.82	5.68	0	3.96	0	0	0	0	1.3
Fatal Acc. Rate	-	0	0	0	0	2.82	0	0	0	0	0	0	0	.174

Table III-24

## Total and Normal Data:

By Aircraft, Air Carrier and Crew Size (Cont'd.)

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
<b>Douglas DC-9</b>														
Total Accidents	1	2	6	3	7	7	6	5	0	4	2	1	2	47
Normalized Accident Total	1	2	5	3	5	6	4	2	0	4	2	0	2	36
Departures - All Services	.319	.710	1.018	1.099	1.139	1.166	1.161	1.114	1.107	1.174	1.202	1.240	.16	13.615
Total Accident Rate	3.13	2.92	5.89	2.73	6.15	6.00	5.17	4.49	0	3.41	1.664	.806	2.51	3.452
Normalized Accident Rate	3.13	2.92	4.91	2.73	4.39	5.15	3.44	1.79	0	3.41	1.664	0	1.724	2.643
Fatal Accidents	1	1	1	1	3	2	1	1	0	0	1	0	0	12
Fatal Accident Rate	3.13	1.41	0.98	0.91	2.63	1.71	0.85	0.90	0	0	.832	0	0	.883
<b>Two Man Crew Operations BAC 1-11/DC-9/B-737</b>														
Total Accidents	2	3	6	4	7	7	7	8	0	4	2	1	1	54
Normalized Accident Total	2	3	5	3	5	6	5	2	0	4	2	1	2	43
Departures - All Services	.504	.912	1.242	1.285	1.302	1.333	1.358	1.374	1.375	1.720	1.581	1.652	1.654	12.293
Total Accident Rate	3.97	3.29	4.83	3.11	5.38	5.25	4.39	5.82	0	2.32	1.265	1.210	3.25	3.313
Normalized Accident Rate	3.97	3.29	4.03	2.33	3.84	4.50	3.68	1.46	0	2.32	1.265	.605	1.224	1.317
Fatal Accidents	2	1	1	1	3	2	1	1	0	0	1	0	0	11
Fatal Accident Rate	3.97	1.10	0.81	0.79	2.30	1.50	0.74	0.73	0	0	.663	0	0	1.751
<b>Three Man Crew Operations B-737</b>														
Total Accidents	-	1	0	1	1	1	4	0	1	0	0	2	-	11
Normalized Accident Total	-	1	0	1	1	1	2	0	1	0	0	0	-	11
Departures - All Services	-	.073	.304	.354	.340	.355	.352	.271	.252	268	.206	.271	.24	1.32
Total Accident Rate	-	13.70	0	2.82	2.94	2.82	11.36	0	3.97	0	0	9.105	.24	1.31
Normalized Accident Rate	-	13.70	0	2.82	2.94	2.82	5.68	0	3.97	0	0	0	0	1.31
Fatal Accidents	-	0	0	0	0	1	0	0	0	0	0	0	0	1
Fatal Accident Rates	-	0	0	0	0	2.82	0	0	0	0	0	0	0	1.31

Total and Normal Data:

By Aircraft, Air Carrier and Crew Size (Cont'd.)

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Table III-26

## Total and Normal Data:

By Aircraft, Air Carrier and Crew Size (Cont'd.)

Boeing 737 By Aircraft		1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	Total
United <sup>1</sup>														
Total Accidents	-	1	0	0	1	0	1	0	0	0	0	0	1	4
Normalized Accident Total	-	1	0	0	1	0	1	0	0	0	0	0	0	3
Departures - All Services	-	.045	.165	.185	.144	.145	.145	.146	.138	.117	.117	.126	.152	1.603
Total Accident Rate	-	22.73	0	5.43	5.43	0	6.94	0	0	0	0	0	6.579	2.483
Normalized Accident Rate	-	22.73	0	5.43	5.43	0	6.94	0	0	0	0	0	0	1.851
Fatal Accidents	-	0	0	0	0	0	1	0	0	0	0	0	0	1
Fatal Accident Rate	-	0	0	0	0	0	6.94	0	0	0	0	0	0	.621
Western <sup>2</sup>														
Total Accidents	-	0	0	0	0	0	0	1	0	1	0	0	1	3
Normalized Accident Total	-	0	0	0	0	0	0	0	0	1	0	0	0	2
Departures - All Services	-	.019	.076	.081	.088	.090	.090	.091	.079	.071	.072	.072	.069	.643
Total Accident Rate	-	0	0	0	0	0	0	10.99	0	14.08	0	0	14.423	3.421
Normalized Accident Rate	-	0	0	0	0	0	0	0	0	14.08	0	0	0	1.721
Fatal Accidents	-	0	0	0	0	0	0	0	0	0	0	0	0	0
Fatal Accident Rate	-	0	0	0	0	0	0	0	0	0	0	0	0	0
Aloha <sup>3</sup>														
Total Accidents	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Normalized Accident Total	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Departures - All Services	-	-	.019	.021	.021	.021	.026	.029	.030	.030	.033	.033	.039	.324
Total Accident Rate	-	-	0	0	0	0	0	0	0	0	0	0	0	2.064
Normalized Accident Rate	-	-	0	0	0	0	0	0	0	0	0	0	0	1.032
Fatal Accidents	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Fatal Accident Rate	-	-	0	0	0	0	0	0	0	0	0	0	0	0

<sup>1</sup>All 3 Man Crew Operations<sup>2</sup>All 3 Man Crew Operations<sup>3</sup>3 Man Crew Thru 11/72 2 Man Crew Thereafter. All Departures for 1969 Thru December 31, 1972 Allocated to 3 Man Crew Operations



Table III-27

## Total and Normal Data:

By Aircraft, Air Carrier and Crew Size (Cont'd.)

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
<b>Boeing 737 By Aircarrier</b>														
Frontier <sup>4</sup>														
Total Accidents	-	-	0	0	0	0	3	0	0	0	0	0	0	3
Normalized Accident Total	-	-	0	0	0	0	2	0	0	0	0	0	0	2
Departures - All Services	-	-	.005	.019	.030	.033	.041	.045	.049	.063	.073	.086	.102	.553
Total Accident Rate	-	-	0	0	0	0	73.17	0	0	0	0	0	0	5.425
Normalized Accident Rate	-	-	0	0	0	0	48.78	0	0	0	0	0	0	3.616
Fatal Accidents	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Fatal Accident Rate	-	-	0	0	0	0	0	0	0	0	0	0	0	0
<b>Piedmont<sup>5</sup></b>														
Total Accidents	-	0	0	0	1	0	1	0	0	0	0	0	0	2
Normalized Accident Total	-	0	0	0	1	0	1	0	0	0	0	0	0	2
Departures - All Services	-	.009	.034	.042	.049	.053	.064	.067	.075	.077	.076	.073	.064	1.08
Total Accident Rate	-	0	0	0	20.41	0	15.62	0	0	0	0	0	0	2.824
Normalized Accident Rate	-	0	0	0	20.41	0	15.62	0	0	0	0	0	0	2.824
Fatal Accidents	-	0	0	0	0	0	0	0	0	0	0	0	0	0
Fatal Accident Rate	-	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Wein<sup>6</sup></b>														
Total Accidents	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Normalized Accident Total	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Departures - All Services	-	-	.005	.006	.008	.008	.009	.009	.015	.016	.014	.016	.014	.014
Total Accident Rate	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Normalized Accident Rate	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Fatal Accidents	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Fatal Accident Rate	-	-	0	0	0	0	0	0	0	0	0	0	0	0

43 Man Crew Thru 9/76 2 Man Crew Thereafter. All Departures for 1969 Thru Dec. 31, 1976 Allocated to 3 Man Crew Operations.

53 Man Crew Thru 2/73 2 Man Crew Thereafter. All Departures for 1969 Thru Dec. 31, 1973 Allocated to 3 Man Crew Operations. However, the One 1973 Accident is Properly Charged to 2 Man Crew Operations.

63 Man Crew Thru 1/76 2 Man Crew Thereafter. All Departures for 1969 Thru Dec. 31, 1976 Allocated to 3 Man Crew Operations.

Table III-28

Total and Normal Data:  
By Aircraft, Air Carrier and Crew Size (Cont'd.)

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	Total <sup>1</sup>
<b>Boeing 737 By Aircarrier</b>											
<b>Air California<sup>7</sup></b>											
Total Accidents	—	0	0	0	0	0	0	0	0	0	0
Normalized Accident Total	—	0	0	0	0	0	0	0	0	0	0
Departures — All Services	—	.006	.021	.020	.027	.027	.029	.030	.031	.033	.334
Total Accident Rate	—	0	0	0	0	0	0	0	0	0	0
Normalized Accident Rate	—	0	0	0	0	0	0	0	0	0	0
Fatal Accidents	—	0	0	0	0	0	0	0	0	0	0
Fatal Accident Rate	—	0	0	0	0	0	0	0	0	0	0
<b>Southwest<sup>8</sup></b>											
Total Accidents	—	—	—	—	0	0	0	0	0	0	0
Normalized Accident Total	—	—	—	—	0	0	0	0	0	0	0
Departures — All Services	—	—	—	—	.006	.011	.011	.012	.017	.022	.144
Total Accident Rate	—	—	—	—	0	0	0	0	0	0	0
Normalized Accident Rate	—	—	—	—	0	0	0	0	0	0	0
Fatal Accidents	—	—	—	—	0	0	0	0	0	0	0
Fatal Accident Rate	—	—	—	—	0	0	0	0	0	0	0
<b>Air Florida<sup>9</sup></b>											
Total Accidents	—	—	—	—	—	—	—	—	—	—	—
Normalized Accident Total	—	—	—	—	—	—	—	—	—	—	—
Departures — All Services	—	—	—	—	—	—	—	—	—	—	—
Total Accident Rate	—	—	—	—	—	—	—	—	—	—	—
Normalized Accident Rate	—	—	—	—	—	—	—	—	—	—	—
Fatal Accidents	—	—	—	—	—	—	—	—	—	—	—
Fatal Accident Rate	—	—	—	—	—	—	—	—	—	—	—

<sup>7</sup>1976 Airline Major Operations

Table III-29

## Total and Normal Data:

## By Aircraft, Air Carrier and Crew Size (Cont'd.)

Boeing 737 Departures

<u>Air Carrier</u>	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	TOTAL
(Total 2- & 3-Man Crew)														
United		.045	.165	.185	.144	.145	.146	.138	.117	.117	.128	.152	.127	1.609
Western		.019	.076	.081	.088	.090	.091	.079	.071	.072	.072	.069	.064	.872
Alouha			.019	.021	.021	.026	.029	.030	.030	.033	.037	.039	.039	.324
Frontier			.005	.019	.030	.033	.041	.045	.049	.063	.073	.086	.109	.553
Piedmont		.009	.034	.042	.049	.053	.064	.067	.075	.077	.076	.073	.089	.708
Wein			.005	.006	.008	.008	.009	.009	.015	.016	.014	.016	.019	.125
Air California		.006	.021	.020	.027	.027	.029	.030	.031	.033	.035	.036	.039	.334
Southwest					.006	.011	.011	.012	.017	.022	.035	.055	.076	.245
Air Florida													.017	.017
<u>TOTAL</u>		.079	.325	.374	.373	.393	.420	.410	.405	.433	.470	.526	.579	4.787

Table III-30

## Total and Normal Data:

## By Aircraft, Air Carrier and Crew Size (Cont'd.)

Boeing 737 Departures

<u>Air Carrier</u>	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	TOTAL
<u>(3-Man Crew)</u>														
United		.045	.165	.185	.144	.145	.146	.138	.117	.117	.128	.152	.127	1.609
Western		.019	.076	.081	.088	.090	.091	.079	.071	.072	.072	.069	.064	.872
Frontier			.005	.019	.030	.033	.041	.045	.049	.063				.285
Wein			.005	.006	.008	.008	.009	.009	.015	.016				.076
Piedmont		.009	.034	.042	.049	.053	.064							.251
Aloha			.019	.021	.021	.026								.087
<u>TOTAL</u>		.073	.304	.354	.340	.355	.351	.271	.252	.268	.200	.221	.191	3.180
<u>(2-Man Crew)</u>														
Air California		.006	.021	.020	.027	.027	.029	.030	.031	.033	.035	.036	.039	.334
Southwest					.006	.011	.011	.012	.017	.022	.035	.055	.076	.245
Aloha							.029	.030	.030	.033	.037	.039	.039	.237
Piedmont								.067	.075	.077	.076	.073	.089	.457
Frontier											.073	.086	.019	.268
Wein											.014	.016	.019	.049
Air Florida													.017	.017
<u>TOTAL</u>		.006	.021	.020	.033	.038	.069	.139	.153	.165	.270	.305	.388	1.607

Appendix IV

RELATIONSHIP BETWEEN CREW SIZE AND  
NUMBER OF VIOLATIONS OF FAA REGULATIONS

March 20, 1981

DEPARTMENT OF TRANSPORTATION  
FEDERAL AVIATION ADMINISTRATION  
Office of Aviation Policy and Plans

IV-1

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The purpose of this analysis is to determine if the size of the flight crew is related to the safety of jet aircraft operations, as measured by the violation of FAA regulations by flight crews aboard common, scheduled air carrier, jet aircraft (B-707, B-727, B-737, B-747, DC-8, DC-9, DC-10, BAC-111, L-1011).

#### DATA BASE

Reported violations of FAA regulations have only recently been stored in a computer data base, and more work is required to make the data base complete and current. The data base is revised frequently, such as when final actions are taken on violations reported earlier. (Final action may be, for example, nonaction, civil penalty, suspension of certificate, or a warning notice.) The information contained in the data base includes, for example, violation date, aircraft type, violator's position, air carrier, regulation violated, and final action. The nature of the violation may be inferred from the specific regulation cited and from a two digit code referring to a violation area.

Two methodological objections to using the computer data base in this analysis are:

- 1) The constant revisions to the data base would make duplication of the analysis difficult in the future; and
- 2) Inferring the nature of the violation from the codes provided may lead to errors. A more reliable description of each violation is desirable.

Fortunately, a subset of the data base that was published by the FAA solves these two problems. These data are in "Air Carrier Enforcement History, January 1975-January 1980," available from:

Flight Standards National Field Office  
Safety Data Branch, AFO-850  
P.O. Box 25082  
Oklahoma City, Oklahoma 73125

The history is a sample of violations, specifically those violations which were committed during the five years covered and on which final action was also taken during those five years. Each violation is described in a phrase or sentence. Aircraft type is not included, so reference to the computer data base is required, although this information is not always included there.

Departure data are used as the measure of flight activity because most violations occur in the airport area. The departure data are those contained in the AIRMARKET data base supplied by The Computer Company, which obtains these data from CAB Form 41. Departure data for Pacific

Southwest Airlines, Air California, and Southwest Airlines were obtained directly from the companies. Air Florida could not supply such data, and thus it is the only scheduled air carrier not included in the analysis.

#### METHODOLOGY

"Air Carrier Enforcement History" contains violations committed by flight crews, flight attendants, mechanics, and others. Only violations committed by flight crews of scheduled air carriers are relevant to this analysis, so the first step is to identify those violations.

The aircraft type involved in each violation is also relevant to this analysis, but this information is not listed in "Air Carrier Enforcement History." The FAA maintains a record of each potential violation which is reported, however, and this record usually includes the aircraft type. The second step, therefore, is to match these two data sources and build a file of violations for which the aircraft type is known. There are 279 such violations. About 40 violations would have been added had the aircraft information been available. There is no reason to assume that the exclusion of these 40 violations introduces any bias.

Also of interest is the nature of each violation. Each report of a potential violation includes a code indicating the kind of violation allegedly committed, but a more precise, descriptive report of the violation found to have been committed is included in "Air Carrier Enforcement History." These descriptions were used to assign each violation to one of 26 categories. The categories were created both to aid in the understanding of the kinds of violations committed and to identify violations which may not be relevant to this analysis. Appendix 1 contains a list of the 26 categories and examples of violations within some categories.

A review of the 279 violations revealed two data problems which deserved attention:

- 1) All members of a flight crew were sometimes cited for the same violation during the same trip.
- 2) Some violations were cited for actions omitted or committed before the aircraft was actually being operated by the crew.

It was decided that in the first case above, only one violation per crew was appropriate for this analysis. In the second case above, it was decided that the actions of the flight crew before operating the aircraft, such as failing to possess a current medical certificate, did not meet the intent of this analysis. That is, the size of the flight crew was assumed to be unrelated to such violations. Accordingly, any inappropriate violations due to multiple citations and any pre-taxi violations were removed from the data base. Fifty-five multiple

violations and then subtracting pre-taxi violations were removed, yielding 185 violations hereafter referred to as "normalized violations." Appendix 2 summarizes violations by category and by aircraft type and indicates violations removed as duplicates. Appendix 3 lists the categories of violations removed from the data base due to being pre-taxi violations.

Total violations, normalized violations, and departures were summed for two-crew aircraft (BAC-1-11, DC-9, and two-crew B-737) and three-crew aircraft (all others). Rates of violations per million departures were calculated for each crew size, and chi-square tests were performed to test the hypothesis that there is no relation between crew size and the number of violations.

### RESULTS

The rate of total violations per million departures is 13.11 for two-crew aircraft and 11.75 for three-crew aircraft. The chi-square test yields a p-value greater than .37. This offers no evidence of a relation between crew size and the number of violations.

The rate of normalized violations per million departures, the preferred measure, is 8.18 for two-crew aircraft and 8.06 for three-crew aircraft. The chi-square test yields a p-value greater than .90. This also offers no evidence of a relation between crew size and the number of violations.

### CONCLUSION

Samples of 2-crewmember violations and 3-crewmember violations, excluding duplicate and pre-taxi violations, were subjected to a chi-square test of independence to determine if evidence suggests a relationship between crew size and the number of violations. The resulting test statistic was so small that with 90 percent probability it was due to sampling error. Therefore, it may be concluded with confidence that no relationship exists between crew size and the number of violations.

A detailed breakdown of departures, total violations, and normalized violations for each aircraft is included as Table 1. A summary of results for each crew size is included as Table 2.



**TABLE 1**  
**U.S. AIR CARRIER VIOLATIONS (1975-1979)**

	BAC-111	DC-9	2-Man B-737	3-Man B-737	B-747	DC-8	B-707*	DC-10	L-1011	B-727	Total
Departure (x10 <sup>6</sup> )	0.545	5.844	1.317	1.125	0.440	0.276	1.347	0.699	0.525	10.733	24.851
Total Violations	5	75	21	7	13	7	33	14	9	95	274
Violations Removed											
-Multiple Violations	0	19	4	1	3	1	6	4	3	14	55
-Pre-Taxi Violations	0	10	5	1	0	1	4	4	1	13	39
Normalized Violations	5	46	12	5	10	5	23	6	5	68	185

\*Includes data for B-720.

TABLE 2  
SUMMARY OF VIOLATION DATA BY  
NUMBER OF PERSONS IN CREW

	2-Crew	3-Crew	Total
Departures ( $\times 10^6$ )	7.706	15.145	22.851
Total Violations	101	178	279
Normalized Violations	63	122	185
Total Violation Rate (Per $10^6$ Departures)	13.11	11.75	12.21
Normalized Violation Rate (Per $10^6$ Departures)	8.18	8.06	8.10

VIOLATION CATEGORIES

1. Noncompliance With ATC Instructions.

(Also, e.g.,  
Noncompliance with tower instructions;  
Failed to obey ATC instructions;  
Failed to follow ARTC instructions.)

2. Deviation from ATC Assigned Altitude/Course.

(Also, e.g.,  
Failed to maintain assigned altitude;  
Allowed aircraft to get too low;  
Flew wrong magnetic heading;  
Penetrated prohibited area;  
Deviated from company specified route;  
Deviated from flight plan track;  
Descended below ATC authorized altitude;  
Descended and crossed VOR at wrong altitude.)

3. Failure to Adhere to ATC Clearance.

(Also, e.g.,  
Deviated from departure clearance;  
Failed to follow ATC landing clearance.)

4. Accident During Taxiing.

(Also, e.g.,  
Began taxi for takeoff and ran into ground  
support equipment;  
Struck another aircraft during taxi;  
Ran off taxiway into soft ground;  
Used excessive power on taxi causing damage  
to light aircraft.)

5. Operating Aircraft Without all Necessary Equipment.

(Also, e.g.,  
Operated aircraft when not meeting MEL requirements;  
Conducted over water flight with Navigator's  
Periscopic Sextant not aboard;  
Failed to assure APU fire extinguisher was operable;  
Operated aircraft with inoperative stall stick shaker.)

6. Improper Action when Weather Below Minimum.

(Also, e.g.,

Landed when weather was below authorized minimums;  
Made landing and takeoff when weather was below  
authorized minimums.)

7. Improper Landing Technique.

(Also, e.g.,

Allowed copilot trainee to make improper landing  
which damaged aircraft;  
Flight manual landing procedures not followed  
resulting in loss of aircraft;  
Allowed aircraft to depart runway during landing;  
Careless handling of aircraft resulted in hard  
landing with considerable damage.)

8. Improper Preflight Fuel and Ice Techniques.

(Also, e.g.,

Failed to assure aircraft was refueled  
prior to takeoff;  
Exceeded authorized fuel load resulting in dumping  
excess before landing;  
Departed airport with ice accumulation adhering  
to aircraft;  
Failed to have aircraft deiced before takeoff.)

9. Failure to Comply with Various Established Procedures.

(Also, e.g.,

Failed to abort takeoff;  
Noncompliance with aircraft preflight requirements;  
Noncompliance with departure procedure when  
hauling Class "A" explosives;  
Aborted takeoff after aircraft had exceeded  
takeoff decision speed.)

10. Landing on or Approaching Wrong Runway.

(Also, e.g.,

Landed on taxiway;  
Allowed Captain to initiate takeoff from taxiway;  
Landed on closed runway.)

11. Taxiing Across Runway Without Clearance.

(Also, e.g.,

Taxied aircraft onto taxiway for which he did  
not have clearance;  
Noncompliance with ATC taxi instructions.)

12. Failure of Crew to Use Seat Belt, Harness, or Oxygen Mask.

13. Landing or Takeoff Without Clearance.

(Also, e.g.,

Operated in traffic area of military base  
without tower approval;)

14. Long or Short Landing.

(Also, e.g.

Ran off end of runway during landing.)

15. Failure to Log or Report Mechanical Failures.

16. Failure to Heed Altitude or Speed Restrictions.

(Also, e.g.,

Exceeded authorized airspeed.)

17. Failure to Comply with Weight or Balance Restrictions.

18. Unauthorized Personnel on Flight Deck.

(Also, e.g.,

Directed Flight Attendant to occupy jump seat  
on takeoff and landing;  
Captain allowed passengers on flight deck.)

19. Access to Flight Deck Denied to FAA Inspector.

20. Failure to Comply with Proficiency Certification Requirements.

(Also, e.g.,

Failed written test and DC-10 simulator check;  
Failed to appear for reexamination.)

21. Failed to Comply with Medical Certification Requirements.

(Also, e.g.,

Operated with outdated medical certificate;  
Failed to appear for reexamination;  
Did not have medical certificate in possession.)

22. Landing at or Approaching Wrong Airport.

23. Unauthorized Personnel at Controls.

24. Failure to Comply With Airworthiness Requirements.

(Also, e.g.,

Flew unairworthy aircraft, fuel leaking into cabin;  
Ferried DC-9 with one engine unairworthy.)

25. Failure to Remove Landing Gear Lockpin Before Departure.

26. Miscellaneous:

Failed to report final approach fix on  
instrument approach;  
Computed wrong landing data;  
Conducted flight when separate seat and belt  
not available for each passenger;  
Noncompliance with ILS localizer intercept altitude;  
Used unauthorized signal causing unnecessary  
evacuation;  
Neglected to turn on "No Smoking" sign  
before landing;  
Crew became disoriented in holding pattern  
resulting in unsafe condition.)

## VIOLATION OF AIRCRAFT TYPE

(Number In Parentheses are Violations Remaining After Evaluation of Implications, Absence of Parentheses Indicates No Implications)

Violation Category	BAC-III	FAR	2-Man Pilot	Crew Member	Pilot In Charge	Co-Pilot	E-200	A-7D	F-4U	Total
Noncompliance with ATC instructions	0	16 (9)	0	1	2 (1)	1	1	1	1	32 (23)
Deviation from ATIS at initial altitude/clearance	0	10 (8)	5 (3)	1	1 (1)	2	6 (5)	0	4 (2)	41 (30)
Failure to adhere to ATC clearance	0	8 (6)	3 (2)	0	0	0	2 (1)	2 (1)	0	24 (18)
Accident during taxiing	0	6	0	0	4	0	2	1	1	19
Operating aircraft without all necessary equipment	0	1	4 (2)	0	0	2 (2)	0	2	0	11 (9)
Improper call to tower weather below minimum	1	0	0	1	1	0	0	0	0	16 (12)
Improper landing technique	1	0	0	1	0	0	4	0	0	15 (10)
Improper pre-flight inspection and takeoff procedure	1	0	1	1	0	0	0	1	1	32 (24)
Failure to comply with wind velocity restrictions for approach	0	0	0	0	0	0	2	0	0	2 (2)

APPENDIX 2 (Continued)

VIOLATIONS BY AIRCRAFT TYPE

Violation Category	DC-10	747-200	747-300	747-400	747-500	747-600	747-700	747-800	747-900	747-1000	747-1100	747-1200	Total
Landing on or approaching wrong runway	1	2	1	0	0	0	0	1	0	0	0	6 (3)	11 (2)
Taxiing across runway without clearance	1	3	0	0	0	0	1	0	0	0	2 (1)	3 (2)	10 (2)
Failure of crew to use seat belt, harness, or oxygen mask	0	2 (1)	1	2 (1)	0	0	0	0	0	2 (1)	0	4	11 (8)
Landing or takeoff without clearance	0	3 (2)	1	0	0	0	0	0	0	1	0	2	7 (4)
Long or short landing	0	3	0	0	0	0	0	0	0	0	1	1	5
Failure to log or report mechanical failures	1	2	0	0	1	0	1	0	0	0	0	0	5
Failure to heed altitude or speed restrictions	0	1	0	0	0	0	2 (1)	0	0	0	0	2 (1)	5 (3)
Failure to comply with weight/balance regulations	0	3 (2)	1	0	0	0	0	0	0	0	0	1	5 (4)
Unauthorized personnel on flight deck	0	0	1	0	0	0	0	1	0	1	0	2	5
Access to flight deck denied to FAA inspector	0	0	0	0	0	0	1	0	0	0	0	3	4



# APPENDIX 2 (Continued)

## VIOLATIONS BY AIRCRAFT TYPE

Violation Category	BAC-111	DC-9	2-Man B-727	3-Man B-727	B-727	DC-10	DC-10	L-1011	B-727	Total
Failure to comply with Proficiency Certification Requirements	0	1	0	0	0	0	0	0	1	1
Failure to comply with Medical Certification Requirements	0	0	0	0	0	0	0	0	0	0
Landing at an airport wrong airport	0	0	0	0	0	0	0	0	0	0
Unauthorized takeoff at airport	0	0	0	0	0	0	0	0	0	0
Failure to comply with Airframe Inspection Requirements	0	0	0	0	0	0	0	0	0	0
Failure to remove log book gear before flight departure	0	0	0	0	0	0	0	0	0	0
Miscellaneous	0	0	0	0	0	0	0	0	0	0
	75 (56)	21 (17)	0 (0)	0 (0)	0 (0)	33 (27)	14 (10)	0 (0)	95 (81)	279 (224)

VIOLATION CATEGORIES DEFINED AS  
PRE-TAXI VIOLATIONS

- o Failure to Comply with Weight or Balance Regulations
- o Operating Aircraft Without all Necessary Equipment
- o Improper Preflight Fuel and Ice Techniques
- o Failure to Comply with Airworthiness Requirements
- o Failure to Remove Landing Gear Lockpin Before Departure
- o Failure to Comply with Proficiency Certification Requirements
- o Failure to Comply with Medical Certification Requirements
- o Miscellaneous:
  - Separate Seat and Belt Not Available for each Passenger (DC-10)

DATE  
FILME

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